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Principles and p

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Cider apples, ciders,
Cider Juice, cider products,
Yeasts, fermentation;
Cider preservation,
Cider production,
" analysis,
Apple pomace,

True

THE
INCIPLES AND PRACTICE OF CIDER-MAKING

by

VERNON L. S. CHARLEY, B.Sc., Ph.D.

late of University of Bristol Agricultural and Horticultural
Research Station, Long Ashton

assisted by

PAMELA M. MUMFORD

WITH 36 *TABLES AND* 86 *ILLUSTRATIONS*

TRANSLATION OF THE THIRD AND LAST EDITION (1928) OF

LA CIDRERIE

by Professor G. WARCOLLIER

late Director of the Pomological Research Station, Caen,
and Fellow of the French Academy of Agriculture

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To

PROFESSOR B. T. P. BARKER, M.A.
late Director of the University of Bristol
Agricultural and Horticultural Research Station
Long Ashton

whose gracious personality, wise direction and unique knowledge of all fruit juice and cider subjects were happy influences on my fifteen years in the Fruit Products Section at Long Ashton, and
whose long example of devoted service to the
horticultural community was instrumental
in first arousing a desire to dedicate
my endeavours to the interests of
the English fruit-growing
industry.

TRANSLATOR'S PREFACE

THIS present translation owes its inception to the fact that no comprehensive textbook covering the cider industry exists in he English language. This unfortunate gap in our technical iterature came as a challenge to me after a few years' experience in the Cider Department at Long Ashton had emphasised the need for an English work to meet the needs of the expanding cider industry. A meeting of cider-makers in Somerset broached the matter of a translation in 1936; arrangements for publication were discussed in the English Channel in a furious gale *en route* for a French Cider Conference in 1938, but it was not until April 1947 that the work was seriously undertaken as a relief from other mental activities of an altogether exceptional intensity.

The translation is now offered chiefly to those interested in the underlying *principles* of cider-making, and the fact that the last edition of *La Cidrerie* was dated 1928 does not prejudice the translation from this point of view. Very few new basic principles have been published since that date and except for the introduction of new types of plant the industry may be regarded as having become relatively static. In an attempt to bring the practical side of the book up-to-date, I have introduced a short section at the end of those chapters where some flavour of modernity was considered desirable. These sections are purposely couched in the briefest terms for two reasons:

(i) It would have been improper to introduce so much new material into Professor Warcollier's work as to make it, in fact, a new book.

(ii) I did not wish to steal the thunder from anyone who might be intending to produce an entirely new English textbook on cider-making.

Many paragraphs of *La Cidrerie* have been deleted. The photographs have largely been replaced by English illustrations, all of them of absolutely up-to-date plant. The English system of measurement has been adopted except in purely scientific cases where cider technicians would naturally use the metric system. The present appearance of this translation would have been quite impossible had it not been for the labours of my colleague Miss Mumford, who apart from being responsible for the secretarial work involved, dealt with the transposition of the tables from French into English units and wrestled with over five hundred pages of the world's worst writing!

Finally, I would like to acknowledge my gratitude to several colleagues and friends who have helped me in my task. Mr. Wilfred Kinnersley, M. Paul Favennec (Managing Director of the Cidreries du Calvados) and M. J. Cousin (Director, Syndicat National des Cidriers et Fabricants d'Eau-de-Vie de Cidre) have been assiduous in their attentions; many members of my Staff have given assistance on various points of scientific importance; and the following firms have very kindly sent to me, often after special preparation for this book, photographs of new plant either made by them or erected in their cider factories:

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February 1949

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CHAPTER I

HISTORICAL

References to cider can be found in writings as far back as the second and third centuries. It has been claimed that cider was known to the Hebrew and African races, but precise evidence as to its use is lacking until the time of the early Roman histories. According to their documents, various European peoples before the Christian era had succeeded in preparing a number of beverages, more or less analogous to cider, from different types of fruit. In Pliny's *Natural History* drinks made from apples and pears are mentioned. Tertullian and St. Augustine record that the Manichées drank liquors extracted from various fruits (*pomorum*) which were similar in nature to wines and in some cases were definitely superior in quality and mellowness.

In the fourth century, Palladius writes of the Roman practice of preparing a wine from pears, and Columella and Macrobius listed thirty-eight varieties of pears and twenty-four varieties of apples. St. Jerome referred to perry (*piracium*) at the end of the fourth century, and appears to be the first writer using this term in the Latin language. He would also seem to have been the first to use the term *sicera*, from which the modern name of cider is derived.

From the books of Strabo it is clear that apples and pears were widely cultivated in Gaul, and that these two fruits served as the bases for various types of beverages.

Further information is found in the Introduction to the Salic Law. In the years A.D. 500-750 attention was paid to the cultivation and preservation of fruit trees in the Frankish Empire and severe penalties were incurred by those who damaged or destroyed such trees.

The development of cider as a beverage in France was very gradual, and occurred chiefly through the monastic orders. The Lives of St. Guénolé and St. Radegonde refer specifically to this beverage by name. The Emperor Charlemagne, in his *Capitulaires*, enforced a law that 'brewers' of cider (*pomacium*), perry and a drink made from grain and herbs should be encouraged to develop their trade.

In Normandy cider was only consumed before the twelfth century in years when there was a shortage of beer or drinks brewed from grain, these latter being then the national beverages. Wine was prepared from the very extensive vineyards in Normandy, but these had completely disappeared by the sixteenth century. The Norman vineyards reached their greatest prosperity in the eleventh and twelfth centuries.

From the sixteenth century cider production developed in Basse-Normandy, in the valleys of the Touques and the Rille, and finally in the Cotentin peninsula and adjoining districts, Haute-Normandy and the Caux area. At the end of the thirteenth century cider merchants had been established at Caen, under the jurisdiction of the municipal authorities. A regulation of 1315 shows that a tax of 10 deniers (5 centimes) was payable per cask of cider to cover its journey up the Seine as far as the Pont-de-l'Arche, this tax being one quarter of that levied on wine.

The religious foundations of High Normandy were well stocked with cider in the fourteenth century. It was in this period that cider slowly superseded the grain and herb beverages and was freely available in the same way and in the same places as wine and beer. In 1371 cider was sold in Caen to nearly the same extent as wine.

The Hundred Years' War and the English occupation, however, were ruinous to the agricultural prosperity of Normandy and cider was subjected to very high taxation. Despite these obstacles, cider had become a very popular beverage in these parts by the fifteenth century.

The next hundred years witnessed many important and fundamental improvements in cider-making practice. Guillaume Dursus, settling at Val-de-Saire in the Cotentin, commenced a study of the various varieties of cider apples and formed a collection of the most suitable sorts, largely basing this selection on grafts brought from his home in Biscay. The example of Dursus was followed by many rich landowners in the cider-apple areas. Gouberville, in his *Journal*, provides a running comnentary on the treatment of fruit trees and the production of ider; he sought far and wide for the best varieties of apples; ross-pollination was introduced and nurseries were built up in which the trees received every possible care and manure was reely used.

The much-famed Julian the Palmer, a Norman squire and physician to Charles IX, wrote his treatise, *De Vino et Pomaceo*, in 1588. In the following year his friend Jacques de Cahaignes, Doctor and Rector of the University of Caen, published a French edition of this famous work. Julian's praise of cider undoubtedly spread the knowledge of this beverage over a very wide area and expanded its sale to a considerable extent.

In the reign of Louis XIII cider production again increased very considerably, this time on account of the almost complete state of dereliction in the Normandy vineyards caused by heavy duties on wine. Consumption of cider through this period was generally on the upgrade, but fluctuations occurred on account of the numerous wars and the penury and misery of the French people even in periods of peace between their various military undertakings.

The agricultural surveyors of the eighteenth century made a very real attempt to clean up the orcharding position, even going so far as to circulate information regarding the suppression of insects. In fact, Parliament in 1732 passed a law imposing on all fruit growers the duty of destroying caterpillars on their trees.

At this period a new influence was felt which was ultimately to exert a most powerful effect on cider-making in general. Agricultural societies sprang into existence and by a system of competitions and prizes encouraged the culture of the cider apple and the production of cider. Many fruit manuals were written by enlightened agriculturalists, amongst them being *Traité des arbres et des arbustes* by Duhamel de Monceau; *Traité complet des arbres à fruits* by the same author; *L'art de cultiver les pommiers, les poiriers et de faire les cidres selon l'usage de la Normandie* by Chambray, published in 1765.

During the eighteenth century nurseries supported by the Crown were established throughout the various provinces concerned with cider-making, and the State initiated much legislation which was designed to improve fruit production.

The fame of cider spread from Normandy to Brittany, Maine, Picardy, l'Ile de France and Orleans, and in the sixteenth and seventeenth centuries the beverage became widely known throughout those parts of France (Louis Duval, *Essai historique sur le cidre et le poiré*).

CHAPTER II

FRENCH CIDER STATISTICS[1]

Production of Cider

Precise details of French cider production cannot be ascertained and the only Government controlled statistics relate to the consumption of cider, these data being provided by the Ministry of Finance through the returns from the tax levied on he sales of cider. However, certain estimates have been made of total production and in Table I (p. 22) are included details of this production for the years 1830-1947. The figures for the years 1944-7 are only approximations.

The extremely variable size of the annual production of cider is amply borne out from a consideration of the data shown in Table I. The figures indicate that there is rarely a crop that can be defined as 'average' in size, but rather a series of crops that fluctuate violently from one extreme to another, a heavy crop being followed by a light harvest. These extremes of the cider apple crops vary by five times as much as the variation in the wine-grape harvests.

As a means of comparing production of cider with that of beer and wines, Table II (p. 23) presents a direct comparison over a long period of years (some data for beer are unavoidably missing).

Local Production.—Normandy and Brittany together achieve three-quarters of the total production of French cider. The localised producing areas, arranged in decreasing order of importance, are as follows: Ille-et-Vilaine, Calvados, Manche, Morbihan, Côtes-du-Nord, Seine-Inférieure, Orne, Eure, Mayenne, Sarthe, Loire-Inférieure, Finistère, Somme.

As an example of variations in production experienced by one such district, Table III (p. 24) sets out the annual figures for what is perhaps the most famous cider-making area in France, i.e. Calvados.

---

[1] This chapter in Warcollier's 1928 edition is so obviously out-of-date and contains such a mass of information of purely national interest that it has been entirely rewritten and only information of general significance is retained. Those original Tables of Warcollier's that are now included have been brought up-to-date with information obtained in 1948 from various Departments of the French Government and from Trade Associations dealing with the cider-making industry in France.

TABLE I.—ANNUAL PRODUCTION OF CIDER IN FRANCE, 1830-1947

Year	*Total production of cider in millions of gallons*	*Year*	*Total production of cider in millions of gallons*	*Year*	*Total production of cider in millions of gallons*
1830	204	1869	94	1908	439
1831	152	1870	422	1909	215
1832	149	1871	47	1910	271
1833	208	1872	101	1911	494
1834	171	1873	300	1912	388·5
1835	221	1874	293	1913	661
1836	196	1875	403	1914	376
1837	176	1876	155	1915	649
1838	159·5	1877	293·5	1916	141
1839	135	1878	262·5	1917	573
1840	144	1879	170	1918	35
1841	196	1880	120	1919	491
1842	227	1881	377	1920	225
1843	236·5	1882	196	1921	576
1844	251	1883	517	1922	382
1845	223	1884	262	1923	352
1846	189	1885	439	1924	628
1847	239	1886	183	1925	217
1848	482	1887	296	1926	270·5
1849	35	1888	215	1927	588
1850	356	1889	81	1928	305
1851	55	1890	244	1929	512
1852	405	1891	204	1930	192
1853	186	1892	333	1931	415
1854	189·5	1893	695	1932	373·5
1855	65	1894	342	1933	429
1856	83	1895	563	1934	509
1857	66	1896	178	1935	295
1858	94·5	1897	149	1936	631
1859	255	1898	234	1937	379
1860	321	1899	458	1938	761
1861	195	1900	647	1939	356
1862	175	1901	280	1940	571
1863	218	1902	203	1941	113
1864	256	1903	125	1942	312
1865	61	1904	901	1943	206
1866	323	1905	106	1944	330
1867	256	1906	491	1945	264
1868	257	1907	74	1946	220
				1947	352

TABLE II.—PRODUCTION OF BEER AND WINES IN FRANCE, 1906-1943
(*data provided by French Ministry of Finance*)

Year	*Production of beer in millions of gallons*	*Production of wine in millions of gallons*	*Year*	*Production of beer in millions of gallons*	*Production of wine in millions of gallons*
1906	320	1,146	1925	433	1,431
1907	313	1,453·5	1926	421	937
1908	324	1,332	1927	423	1,127
1909	313	1,200	1928	359	1,327
1910	336·5	628	1929	465	1,430
1911	395	987	1930	457	1,004
1912	374	1,306	1931	462	1,305
1913	374	972	1932	357·5	1,090·5
1914	220	877	1933	422	1,139
1915	264	449	1934	450	1,719
1916	—	792	1935	380·5	1,673
1917	—	841	1936	356	961
1918	—	990	1937	373	1,195
1919	—	1,196	1938	355	1,327
1920	—	1,233	1939	281	1,518
1921	—	990	1940	235	1,087
1922	—	1,523·5	1941	197	1,047
1923	—	814	1942	289	770
1924	—	1,481	1943	312	902

Production at Farm and Factory.—The major production of cider is undertaken only in those regions where the cider apples are most intensively cultivated. Not only are the cider-makers actuated by economic motives in so doing, but they also have a real interest in maintaining close contact with the actual conditions under which the fruit is grown, and the factories, in particular, pay close attention to questions of variety and condition of the fruit they purchase. A certain tendency, however, has been noted for certain large factories to be established outside the cider apple areas, especially in large towns, such as Paris, the implication being that it is more convenient in some circumstances to transport the fruit to the factory from a distance rather than to be faced with the problem of transporting large bulks of cider over long mileages. In the cider areas, the greater part of the production is in the hands of the farm cider-maker. Ciders so made are used for domestic purposes on the farm and for sale to neighbouring towns, whilst large quantities of a diluted form of cider are also produced for consumption by the workers on the farm. In certain towns, close to cider apple districts, many residents purchase apples and have these supplies pressed into juice by the itinerant cider presses, for which a charge is made on a gallonage basis. The hygienic and economic features of this form of cider-making leave much to be desired.

As an adjunct to this purely agricultural type of cider-making, the establishment of factories of all sizes has radically altered the general shape of the industry. Technical facilities are available which are denied to the farm cider-maker and whilst the quality and stability of cider made in commercial factories has improved to a very remarkable extent in recent years, the quality of farm-made cider still lags behind. Most medium and large sized factories produce cider, eau-de-vie and industrial alcohol. The most appreciable installations utilise about 10,000 tons of apples each year.

TABLE III.—PRODUCTION OF CIDER IN CALVADOS AREA, 1871-1946

Year	*Millions of gallons of cider*	*Year*	*Millions of gallons of cider*	*Year*	*Millions of gallons of cider*
1871	3·4	1896	17·3	1921	53·6
1872	11·2	1897	16·9	1922	25·8
1873	36·4	1898	37·0	1923	29·8
1874	27·3	1899	34·9	1924	63·1
1875	46·7	1900	69·0	1925	21·5
1876	12·2	1901	18·7	1926	26·9
1877	37·7	1902	28·2	1927	39·0
1878	23·1	1903	11·5	1928	33·2
1879	24·5	1904	80·9	1929	49·1
1880	10·0	1905	13·4	1930	24·3
1881	42·2	1906	48·3	1931	41·4
1882	22·7	1907	61·8	1932	31·8
1883	61·7	1908	45·9	1933	51·3
1884	20·5	1909	12·8	1934	53·5
1885	47·9	1910	24·7	1935	49·7
1886	17·8	1911	34·6	1936	76·6
1887	40·5	1912	63·7	1937	50·5
1888	11·7	1913	83·8	1938	71·5
1889	15·6	1914	71·7	1939	50·5
1890	16·5	1915	45·2	1940	45·1
1891	23·6	1916	21·5	1941	11·5
1892	18·0	1917	38·4	1942	40·0
1893	51·7	1918	28·3	1943	34·3
1894	41·8	1919	46·3	1944	60·5
1895	83·1	1920	16·0	1945	19·5
				1946	23·0

Consumption of Cider in France

The main consumption of cider takes place in the cider areas, adjoining districts and many of the largest towns of France. The demand varies with its price (i.e. cider is consumed to a greater extent in years of heavy crops of fruit when correspondingly lower priced ciders are produced therefrom), or according to the wine harvests (i.e. cider is more in demand in years when wine is scarce). Total consumption of cider is most difficult to ascertain, for very large quantities are consumed on the farm and are sent to the distilleries. The only exact figures are for the sales of cider on which a tax is payable, and these figures are presented in Table IV.

TABLE IV.—TAXED CONSUMPTION OF CIDER IN FRANCE, 1900-1947
(figures provided by French Ministry of Finance)

Year	*Consumption of cider in millions of gallons*	*Year*	*Consumption of cider in millions of gallons*	*Year*	*Consumption of cider in millions of gallons*
1900	132	1916	226	1932	69
1901	166	1917	158	1933	104
1902	108	1918	151	1934	106
1903	88	1919	112	1935	101
1904	119	1920	163	1936	97
1905	137	1921	147	1937	124
1906	117	1922	161	1938	114
1907	114	1923	140	1939	98·5
1908	108	1924	199	1940	87
1909	122·5	1925	181	1941	83
1910	119	1926	104	1942	77
1911	160	1927	134	1943	96
1912	151	1928	142	1944	62
1913	168·5	1929	146	1945	147
1914	172	1930	85	1946	84
1915	152	1931	94·5	1947	79

French Exportation and Importation of Cider

Between the years 1904-1913, France exported less than one-thousandth of its production of cider, whilst Germany and Spain developed very large exports of sparkling cider to world-wide markets. The greater part of the exports during this period took the form of liquid provisions for French boats fishing off

Newfoundland and Iceland. A certain amount of information is available concerning the export and import of cider during the period 1904-1943, and this is given in Table V.

TABLE V.—FRENCH IMPORTATION AND EXPORTATION OF CIDER

(figures provided by French Ministry of Agriculture)

Year	*Cider imported (gallons)*	*Cider exported (gallons)*
1904	15,000	537,000
1905	6,000	741,000
1906	7,000	451,000
1907	4,000	599,000
1908	6,000	450,500
1909	9,000	471,000
1910	19,000	337,000
1911	25,000	434,000
1912	17,000	539,500
1913	11,000	505,000
1914	11,000	454,000
1915	15,000	125,000
1916	107,000	217,000
1917	55,000	68,500
1918	135,000	85,000
1919	278,000	102,000
1920	376,000	195,000
1921	73,000	223,500
1922	64,000	254,000
1923	37,000	297,000
1924	15,000	1,486,000
1925	4,500	1,895,000
1926	2,000	1,382,000
1927	609,000	735,000
1928	520,000	454,000
1929	303,000	608,000
1930	112,000	803,000
1931	69,000	419,000
1932	70,000	2,257,000
1933	113,000	726,000
1934	89,000	31,000
1935	34,000	35,000
1936	43,000	35,000
1937	129,000	106,000
1938	139,000	145,500
1939	Nil	Nil
1940	„	„
1941	„	„
1942	„	„
1943	„	„

Cider Production outside France

Many countries have developed industries for cider production and have attempted to initiate an export market for their products, but only insignificant quantities have been imported into France. Amongst these may be mentioned England, America, Canada, Switzerland, Austria, Spain, Belgium and Germany. Spain has achieved some success with its export efforts. Cider is produced chiefly in the provinces of Asturia and Oviedo, and is exported mainly from the ports of Villaviciosa, Gijon, Ribadesella, Bilbao, Santander, Corunna.

In a general way, ciders made outside France do not command a ready acceptance by the French public, but German, Spanish and English ciders have gained considerable popularity in other markets and will undoubtedly prove to be serious competitors with French cider when eventually the French industry enters a trade of which they should have been the natural originators. Spanish ciders were exported to nearly all the South American Republics, whilst Germany had developed, before the last war, a very large export trade in sparkling cider. In 1913 this country officially exported 50,000 bottles of sparkling cider, but in actual fact, more than twenty million bottles left the country labelled 'Champagne', which contained a variety of aerated beverages, often sophisticated liquors made from apples imported from Brittany.

French cider exports in recent years have been made largely to England and Belgium, the medium of transport being in casks. The demand for cider in Great Britain has increased to a very great extent in the past twenty years, for whereas it was formerly consumed almost exclusively in the West of England in the five cider counties, with Bristol as their geographical centre (Devon, Somerset, Gloucester, Worcester, Hereford) the last two decades have seen the introduction of cider as a high class beverage throughout the whole country. Standardised products and a regular high quality has won for the product a widespread acceptance amongst discriminating consumers, to such an extent that the English cider apple crop has been unable to meet the demand. The lack of attention in past years to orcharding conditions had led to a serious position by 1938 and World War II prevented any attempt being made to ameliorate the position. Before the war, large quantities of French bittersweet apples were imported for the purpose both of implementing supplies of home grown cider apples and of providing the necessary high tannin–low acid juices suitable for blending with the sharp culinary varieties which the cider industry were anxious to turn into cider, but which could not be extensively used on account of the shortage of supplies of English bittersweets. In 1925 and 1926, England purchased practically all the cider exported from France. The English production of cider is as difficult to assess as the French output, and in the former country the beverage is not taxed, so that no precise details can be given for actual consumption. It is probable that annual consumption of cider in England amounts to 12-18 million gallons. No eau-de-vie or industrial alcohol is produced from English cider.

Considerable quantities of concentrated apple juice from France, Canada, Australia and Switzerland have also been exported to England for cider-making purposes.

Utilisation of French Cider Apples

Although complete figures for the various ways in which cider apples are used are not available for more than a few years, such data are of considerable interest as they indicate the relative importance of the respective outlets for this crop. Table VI has been prepared for this precise purpose. The figures associated with an asterisk have been given by the French Cider Trade Association, working in conjunction with the Ministry of Finance. The other figures are only estimates, but they have been carefully prepared by experts in close contact with the various industries and are believed to be close approximations to the actual tonnages.

TABLE VI.—UTILISATION OF FRENCH CIDER APPLE CROP

(*figures given in English tons*)

	1938	1939	1940	1941	1942	1943	1944
For cider consumed or distilled at the farm - - -	2,610,585	1,285,341	2,907,199	402,203	893,920	398,489	406,209
,, cider sold by the farmer -	246,110*	228,482*	150,086*	182,151*	216,152*	278,541*	658,627*
,, cider produced by factories	254,415*	212,587*	239,160*	172,235*	212,630*		
,, state alcohol:							
from apples - - -	1,278,869*	436,886*	566,702*	3,149*	541,158*	50,194*	177,156*
from cider - - -	8,100*	984*	403*				
,, confectionery and apple pulp	4,864*	—	3,944*	6,890*	19,684*	46,257*	17,223*
,, export - - - -	114,174	—	132,697	19,746	78,539	7,676	—
,, unfermented apple juice -	196*	—	—	984*	5,314*	6,200*	5,905*

CHAPTER III

COMPOSITION OF THE CIDER APPLE

The apple, considered from the point of view of its outward structure, is composed of two parts; the fruit itself and the peduncle, or stalk. The latter is composed of hard tissue; it supports the fruit and conveys to it the nutritional elements needed for growth during that period in which the fruit is attached to the tree; sometimes the stalk is easily detached from the ripe fruit, on other occasions the attachment is relatively strong.

The stalk contains notable amounts of tannins and other bitter substances, but a twenty-four hour maceration of the stalk tissue with apple pulp does not appear to impart to the juice the flavour of these characteristic flavouring compounds to any appreciable degree.

The Fruit

The fruit consists of pulp, skin and seeds (Figs I and II). The relative proportions of these three types of tissue vary with the variety, size and weight of the apple. Warcollier has shown, as a result of many examinations, that the range of values are as shown below (figures given as per cent of weight of fresh apple material):

Pulp - -	92·1 -	96·95
Skin - -	7·0 -	3·00
Seeds - -	0·9 -	0·05
	100·0	100·00

Total insoluble constituents of the cider apple (skin, seed, cellulose, pectose, insoluble nitrogenous compounds, etc.) amount to 5-6% of the total fruit, thus leaving 94-95% for soluble constituents or *juice*.

Consequently, if the content of sugar, tannin, pectic substances, etc., in a cider apple calculated for one litre of juice is known, the corresponding contents of these constituents in the fruit itself can be determined by multiplying the original figure y $\frac{940}{d}$, d being the weight of one litre of juice expressed in rams. For example, for a juice with specific gravity 1·060 and ontaining 130 g. sugar per litre, the fruit itself would contain pproximately $130 \times \frac{940}{1060} = 115{\cdot}2$ g. sugar per kilogram.

The average weight of apples varies, according to variety, rom 25-180 g. (0·8-6·3 oz.).

Truelle has suggested the following categories:

Very small	up to 35 g. (1·2 oz.)
Small	36-50 g. (1·3-1·7 oz.)
Average	51-65 g. (1·8-2·3 oz.)
Large	66-80 g. (2·3-2·8 oz.)
Very large	above 81 g. (2·9 oz.)

The more detailed description of the various sections of the pple will now be undertaken.

Skin or Epicarp.—This is formed of a layer of polygonal cells vith thick external walls, compactly formed and provided on he exterior with a cuticle of a waxy nature. Sando has studied hese waxy constituents of the apple skin. The dried skins were xtracted first with light petrol ether and subsequently by ether. The first extract contained triacontane, heptacosanol, and crysalline products unidentifiable on account of their presence only n minute quantities.

The ether extract contained an alcohol, $C_{30}H_{48}O_3$ (named nalol), which was obtained as prismatic needles (M.P. 285 °C); t was dextrorotatory and seemed to be a lower homologue of wo isomeric alcohols, oleanol and primol.

Beneath the layer of tissue comprising the skin, is found three or four layers of yellowish collenchymatic tissue with hard memoranes.

The epidermal cells each contain several minute oily droplets within a liquid possessing a granular structure. Louise and Pihier regard these droplets as possessing the appearance, character and reactions of essential oils which contribute to the aroma of the apple. The thick-walled cells release their aromatic constituents only when they are disintegrated by some mechanical means, such as the cider mill (even this only rarely effects complete breakdown), or when they are macerated for a certain time in water, such as in the maceration of the pomace after the withdrawal of the pure juice or in the practice of direct diffusion of the fresh pulp. The action of heat in killing the cells has the same effect.

The skin tissue also contains tannin-like compounds, other bitter substances and colouring materials which provide the apples with their typical hues. The coloured constituents in the skin can be readily demonstrated by macerating the skins of red apples in a slightly acid solution (1 % tartaric acid) and heating for 1 minute at 100 °C. These substances are only slightly soluble in water and juice at temperatures below 50 °C and their solubility increases with higher acidity; they dye wool, paper, etc., oxidise rapidly in the air, and are rendered insoluble and are fixed on the insoluble constituents of the pulp, losing their colour in the process. Sulphur dioxide decolourises these colouring materials and forms stable compounds which are resistant to oxidation. The subsequent removal of sulphur dioxide is followed by a return of the colour in full intensity.

During cider-making, the colouring matters in the skin are oxidised and rendered insoluble simultaneously with some part of the natural tannins, and do not contribute any further to the natural tint of the cider. On the other hand, during the prolonged maceration ('cuvage') of the pulp, the bitter constituents of the skin pass into the juice which acquires a disagreeable bitter flavour.

Pulp.—The mesocarp, or flesh, of the apple is very variable in composition. It may be dry or juicy, soft, woody or hard. It is composed of large regular thin-walled cells filled with a sugary fluid. The cells contiguous to the skin contain grains of chlorophyll when the fruit is green. In all green fruit cells can be seen starch granules, circular, elliptical or polyhedral, the number of these diminishing as the fruit ripens; these grains occur either in isolated units or in groups, their diameters ranging from 5-20 μ.

The interior portions of the flesh tissue are made up of very large cells, arranged in such a way that during growth many air spaces occur between them—these spaces, however, disappear at maturity when the cell walls develop a gelatinous structure. The entire mesocarp is characterised by scattered bundles of woody tissue.

The pulp represents about 92-97 % of the total weight of the

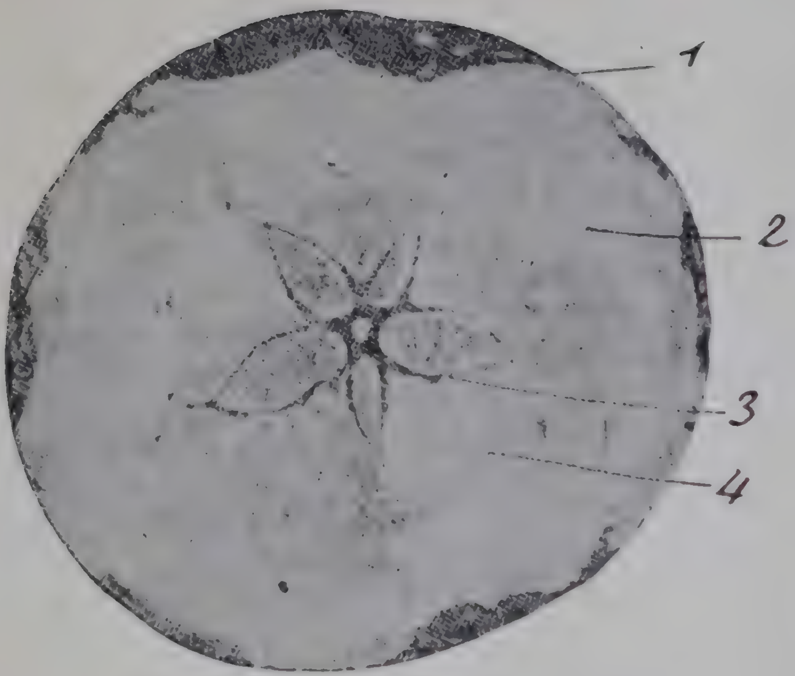

FIG. I. Transverse Section of an Apple

1. *Skin* 2. *Flesh* 3. *Endocarp* 4. *Traces of bundles*

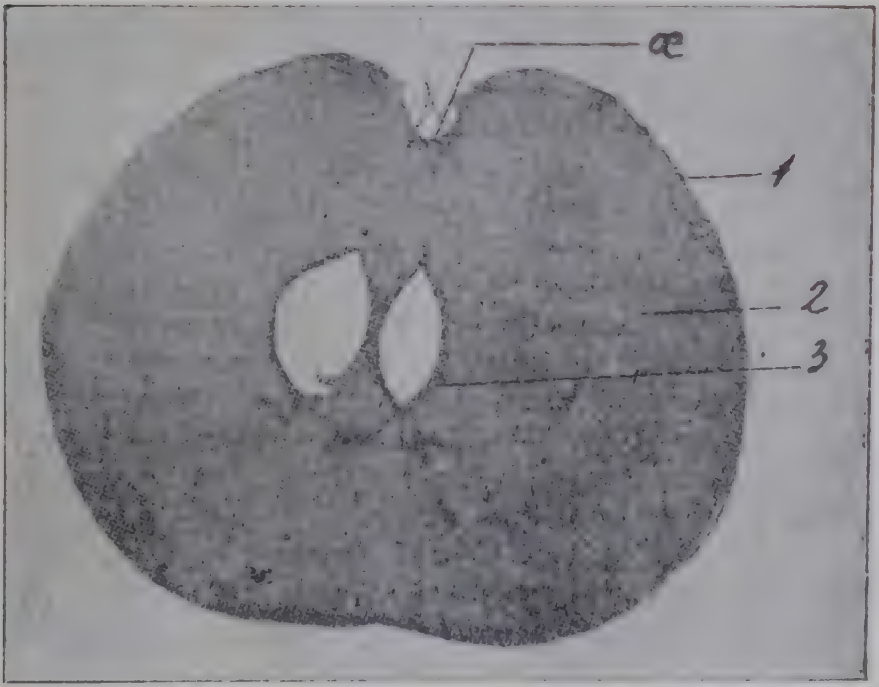

FIG. II. Longitudinal Section of an Apple

œ. *Eye* 1. *Skin* 2. *Flesh* 3. *Hard seed case*

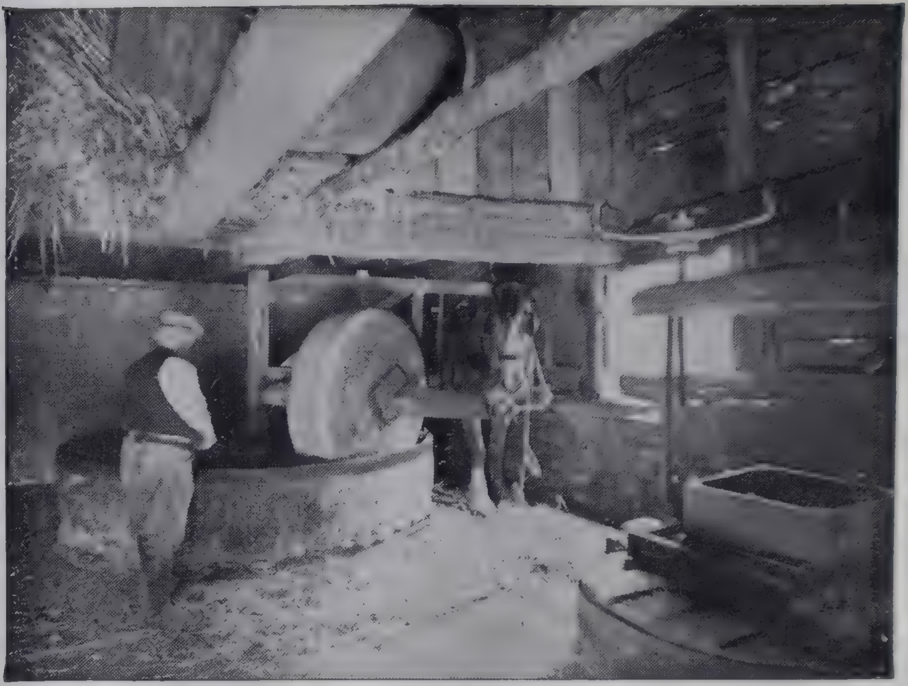

FIG. III. English Stone Mill

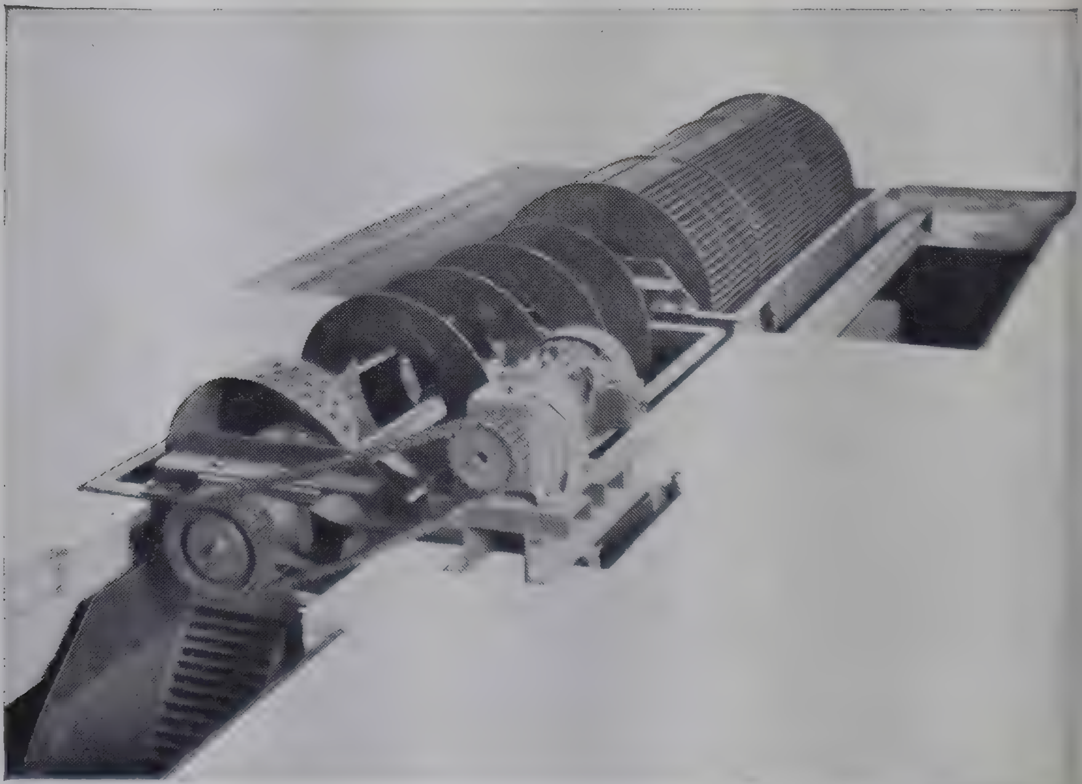

FIG. IV. Watts-Adlam Apple Washer

pple. It is composed of soluble substances which constitute the iice, together with insoluble compounds, such as starch, pectin, ellulose, nitrogenous and mineral materials.

The fibrous tissue and cellulose of the pulp represent 2·5 to ·5% of the pulp. These parts of the apple, together with the kin, seeds, and other insoluble constituents of the pulp, contitute the pomace ('marc'). The pulp is therefore composed f 96·5-97·5% of juice ('moût' or 'jus').

Composition of the Juice

The juice is a syrupy liquid of a density greater than that of vater. This density, according to the type of apple, varies from ·040-1·100. Mixed varieties of apples, as received at cider facories, generally provide a juice with a density varying between ·045 and 1·075.

The gravity is pre-eminently a function of the sugar content f the juice; it is determined by a hydrometer, or more accuately by weighing 100 ml. of filtered juice at a controlled temerature using a specific gravity bottle.

The proportion of water in apple juice is equal to 75-90% of ts weight. The chief juice constituents are water, glucose, laevuose, sucrose, malic acid, tannins, pectic substances, albuminids, fat, minerals and compounds containing nitrogen.

TABLE VII.—COMPOSITION OF FRESH CIDER APPLE JUICES

Composition	*Bedan*	*Noel des champs*	*Saint-Martin*	*Bout-eille*
(Specific Gravity	1·063	1·078	1·060	1·055)
Water %	83·15	80·65	84·34	85·75
Glucose and laevulose %	11·10	13·30	10·00	9·10
Sucrose %	1·40	1·60	1·40	1·30
Malic acid %	0·28	0·26	0·26	0·30
Nitrogenous substances %	0·055	0·042	0·062	0·064
Tannins %	0·15	0·10	0·12	0·13
Pectins and gums %	0·32	0·46	0·51	0·42
Minerals %	0·23	0·32	0·36	0·34
Residual constituents %	3·315	3·268	2·948	2·596
	100·00	100·00	100·00	100·00

The following table shows the maximum, minimum and average figures for the chief constituents in cider apple juices,

TABLE VIII.—CHIEF CONSTITUENTS OF CIDER APPLE JUICES

	Minimum	*Maximum*	*Average*
(Specific Gravity - - -	1·045	1·100	1·060)
Fermentable sugars % (w/v)	8·5	21·0	12·5
Acidity (as malic acid) % (w/v)	0·068	1·37	0·274
Tannins % (w/v) - - -	Trace	1·20	0·3
Pectic substances % (w/v) -	0·05	2·00	0·7

Certain facts concerning some of these basic constituents of apple juice are of interest.

Sugars.—These are composed of glucose, laevulose and sucrose. Their interrelationships have been determined by Truelle, Buignet, Behrend, Kulisch, Lindet and Warcollier.

Glucose ($C_6H_{12}O_6$). This sugar is found in grapes, honey and fruits; it is dextrorotatory and reduces Fehling's solution.

Laevulose ($C_6H_{12}O_6$).—The same three foods also contain laevulose, a sugar that is laevorotatory and also reduces Fehling's solution.

Sucrose ($C_{12}H_{22}O_{11}$).—This may be beet or cane sugar; it is dextrorotatory (+66·5° at 20°C). Sucrose can be inverted by all acids, forming invert sugar which is a mixture of equal weights of laevulose and glucose. The inversion process can be expressed by the following equation:

$$\underset{\text{sucrose}}{C_{12}H_{22}O_{11}} + H_2O = \underset{\text{glucose}}{C_6H_{12}O_6} + \underset{\text{laevulose}}{C_6H_{12}O_6}$$

Practically all yeasts can invert cane sugar—a fact that will be found later to have a special significance in cider-making. The relative proportions of the three sugars in mature fruits are very variable. Sucrose represents between 3-42% of the total sugar, the reducing sugars being responsible for the remainder.

The researches of Warcollier have covered a wide selection of varieties, and show that the reducing sugars can comprise from 9-26·5% glucose and from 73·5-91% laevulose, and that the rotatory power of the reducing sugars is between −54·5° and −80°. Laevulose is present to the extent of 2½ times the glucose content, and the ratio $\frac{\text{glucose}}{\text{laevulose}}$ is never greater than 0·50 and can be as low as 0·09.

Warcollier has published in the *Bulletin Association française mologique*, volume II, 1907, a series of figures on this sugar lationship.

Variety	*Sugar Percentage by Volume*			*Sucrose / Total Sugar*	*Glucose / Laevulose*	*Rotating Power of Reducing Sugars*
	Sucrose	*Glucose*	*Laevulose*			
ly Rouge -	2·8	2·6	8·4	0·20	0·31	−59°
edan - -	3·8	1·9	11·1	0·22	0·17	−72°
réquin rouge	4·4	2·3	8·0	0·29	0·29	−60
oux-Auveque	3·84	1·85	6·66	0·32	0·20	−69°
picé - -	4·2	1·7	7·9	0·30	0·22	−67°

Glucose and laevulose appear to be formed exclusively from ucrose. The greater proportion of laevulose relative to glucose an be explained by assuming that during the normal respiraion of the fruit, glucose disappears more quickly than the other ugar.

The conversion of sucrose into glucose and laevulose is due o the presence of a diastase, 'invertase', which is responsible or the inversion process. This diastase is not stable or active in he milled fruit; it is destroyed by coagulation by the juice annin (Warcollier, *Comptes rendus de l'Académie des sciences*, 6th May 1907).

Sucrose in the apple exists as a result of the degradation of tarch, according to the researches of Lindet. Kayser has suggested that the starch itself originates in the leaves.

Chemical and physical changes occurring in the apples as hey approach maturity have been examined by Synder and by Thatcher, with special reference to the diastatic formation of ucrose from starch.

Starch.—This material is found in considerable quantities in nder-ripe apples. Lindet has published the following results f his work: 'In under-ripe apples the starch is distributed hroughout the whole of the fruit; indeed, it is difficult to notice ny differentiation between the starch content of the mesocarp nd endocarp when a slice of the fruit is immersed in the standard iodine solution used for the purpose. As maturation proeeds, however, the starch disappears from the central portion f the apple. Eventually, the core tissue becomes entirely depleted of starch, the concentration gradually increasing outwards towards the periphery. Often blue strands can be seen assing from the epicarp towards the endocarp, these tissues aving retained part of their original starch; again, starch may be accumulated against the hardened wall of the cells of the endocarp as if it was impossible for the chemical to pass through; in those parts of the fruit where the circulation is relatively inactive, such as protruding sections of the core and tissue near to the stalk, starch remains for a considerable period. Finally, where the apple is bruised and circulation is interrupted, the starch remains indefinitely.'

The starch content of green fruit varies between 5-8%, but at maturity this has fallen to 0·5-1·0%.

Kulisch recognises two groups of apples: those that retain no starch at the time of harvesting (early fruit), and apples which still contain this constituent at this period (late fruit).

Warcollier, however, has examined numerous varieties of early apples, as well as apples ripening on the tree and suitable for immediate milling, and has found that these sorts always show a certain amount of starch (0·2-1·0%).

Malic acid.—The acid content of apples varies considerably according to the variety. Sharp cider apples which are similar in appearance and taste to market fruit often contain more than 1·37% malic acid; in sweet fruit the acidity falls to 0·068%. Such fruits will naturally provide ciders with very variable tastes.

The acidity of the apple is due to the presence of free malic acid, and potassium and calcium malates. Warcollier has shown that cider apples do not contain tartaric acid (*Tartaric acid content of apples, pears, ciders and perries:* Pomological Congress of Havre, 1910).

Malic acid is not evenly distributed throughout the pulp; there is slightly less acidity at the outside of the apple than in the centre.

M. Gerber has noted that in apples that are stored under cover at a temperature of about 15°C. the amount of sucrose formed is in excess of that which would be expected to result from the amount of starch destroyed. The loss of starch plus the loss of acidity, however, corresponds more closely to the gain in sucrose. This observation suggests that in specific cases the natural acids of the apple are utilised in the formation of sugars.

Fruit acids contribute the sharp taste to the juice and a refreshing character to the cider. Ciders deprived of their acidity are flat; ciders with acidities above 0·68-0·80% are harsh and excessively acid.

The acidity of the fruit juice confers a degree of stability on e natural colouring agents which are associated with oxidaon products, probably tannins. Low acid juices rapidly darken colour when in contact with the air, and ciders made thererom have a tendency to darken on exposure to air; juices that re highly acid remain light in colour and provide similarly ight-coloured ciders. Acidities between 0·37-0·55% are most uitable from the point of view of colour development.

The acidity of a juice plays an important part in protecting he juice against bacteria and thus helps to establish a dominant ermentation of the normal yeast type.

The acid content of ciders is less than that of the juices from hich they are prepared; with very acid juices, the malic acid isappears during fermentation often to the extent of 50%, and ometimes more. This phenomenon, caused by yeast and bacerial action, will be discussed later.

Bigelow and Dunbar and also Thompson have confirmed hat free malic acid is the source of the acid character of apples. Grove and Summers have also studied the acidities of juices nd the changes in acidity during fermentation, using the elecrometric method (*Long Ashton Res. Stn. Ann. Rept.*, 1923, p. 98).

Tannin.—The chemistry of the tannin constituents of apples s still obscure. Lindet has established their general properties. Apple tannins do not resemble oak gall tannin, but are more closely related to those of cachou, coffee and quinquina. Thus, hey cause maximum green colouration with salts of iron; they are only slightly soluble in water and alcohol and are insoluble in ether; ammonia colours them pink, and they are coloured brownish-red by potash, sodium hydroxide and alkaline carbonates. Apple tannins precipitate vegetable albumen, gelatin, and salts of lead, copper, mercury, silver, etc.

Tannin is found in special cells in the apple pulp (Mayoux). The salts of iron do not give the characteristic green colour with tannin compounds contained within the living cells of the apple. This important observation suggests that the tannin in the living cells is not in the same state as that which can be so easily shown by ferric chloride in the dry tissue of oak galls; consequently, it may be that tannins in the apple are combined in certain ways that mask their reactions, and that these combined forms are destroyed by heat or by the death of the tissue.

Apple tannin, colourless whilst it is in the cells, becomes coloured in the air by a process of oxidation. If an apple is cut into slices, the colouration process commences immediately; a juice issuing from the press and remaining exposed to the air becomes progressively darker in colour.

Lindet has shown that oxidation of the tannin is due to the action of an oxidase. The tannin is not only oxidised in the juice as it runs from the press; it is also oxidised in the pomace and is 'fixed' on pectic substances and cellulose by a process of "dyeing".

The nitrogenous substances in the crushed apple also combine to some extent with tannin, both becoming fixed on the pomace residue.

Acids inhibit the oxidase activity. This explains why juices rich in acid do not generally darken to any considerable extent in contact with air.

The above considerations indicate that according to the content of the pulps in tannin, oxidase and malic acid, they will provide juices and pomaces which will be more or less darkened in colour in the air and will furnish ciders which will show similar colour characters.

Warcollier has reported the results of experiments which have shown that apple pulp, darkened by air contact, is capable of regaining its original light colour if air is excluded. This is due to a diastase activity, and a reductase reverses the normal oxidase effect (Warcollier, Congrès pomologique Vitré 1904 [*Bulletin Associat. franc. pomologique*, volume I]).

Apple tannin is a strong inhibitor of enzymes; especially is this true of sucrase, and, in certain strengths, tannin reduces considerably the action of pectase, the enzyme which affects the pectins in the juice (Warcollier, *Bulletin Associat. franc. pomologique*, volume II, 1907). Further, the tannin appears to act on certain occasions as an inhibitor of yeasts. Rosenstiehl's investigations made it clear that the astringent compounds in apple juice, if present in high concentrations, exercised a retarding influence on the yeast in such a way that fermentation is prevented whilst cell reproduction is maintained.

It has been demonstrated by Warcollier that apple tannin in a reduced state does not possess this power of retarding yeast growth; in fact, yeast inhibition is due to the presence of oxidised orms of tannins; only those yeasts that are affected by the xidised tannin have their physiological functions profoundly ltered.

Tannin exerts an antiseptic effect on various bacteria which ause certain disorders in cider; this group of compounds can lso be considered as materials which contribute to the keeping properties of ciders. It has often been noted by Warcollier that very bitter ciders with high tannin contents have better keeping qualities than ciders with less tannin, and are better able to resist the action of *Mycoderma vini* and aerobic acetic bacteria.

On account of its property of combining with nitrogenous substances in the juice, and with white of egg, gelatin, and isinglass to form voluminous insoluble precipitates, tannin has a function to perform in fining and clarifying juices and ciders. It is often employed either alone or in combination with other materials, to be discussed later, for artificial clarification of cider.

In concluding this survey of the rôle played by tannin in cider-making, attention must be drawn to the particular cause of the formation of a green colour by tannin and ferric salts under the influence of aerobic conditions. The reaction constitutes a serious deterioration in the cider, known to the French as 'verdissement' but which has no specific equivalent term in English.

A further phenomenon in ciders is called *blackening* and is due to conversion of the normal oxidised form of tannin into a more highly oxidised product with a deeper colour.

There is direct evidence that those ciders that are exceptionally bitter to taste contain very high contents of tannin; but there is not always a direct relationship between astringency and tannin content, suggesting that ciders contain certain specialised bitter compounds other than tannins similar to those already mentioned as being present in the skin and stalk.

Pectic Substances.—These materials possess a complex composition which alters continuously as maturation of the apple proceeds. Pectins are associated in the fruit with such similar compounds as gums and mucilages. According to Frémy, green fruits contain pectose, an insoluble compound, associated with the cell tissue, which can be converted into pectin by the action of acids or of heat. A green apple provides a juice which does not contain pectin; but by boiling the juice with the pomace residue the natural acidity will convert the insoluble pectose into soluble pectin which will confer an added viscosity on the juice.

Mangin showed that pectose is combined in the cell wall of fruits with cellulose as a material called pecto-cellulose. During the maturing of the fruit, the pectose is converted into pectin, and this change in chemical composition produces marked changes in the apple itself—the apple ripens, and the tissue becomes mature and soft.

Pectin is soluble in water to which it contributes viscosity; the pectin is not in true solution but is said to be in the colloidal state. It is gelatinous in form, is precipitated by alcohol, and will not pass through a dialysing membrane.

Pectins are dextrorotatory, but as the rotating power varies from sample to sample it has been conjectured that pectin as it is known in the apple is really a mixture of various compounds whose individual compositions are slightly different from each other.

Frémy discovered in fruits an active enzyme which he called pectase, which converts pectin in aqueous solution into an insoluble gelatinous material. This reaction constitutes 'pectic fermentation' which will be discussed later.

Bertrand and Mallèvre have extracted the pectic substances from various tissues of a large number of plants. The vegetable tissues contain pectose and pectin, accompanied by the enzyme pectase. These two workers also showed that pectase extracted from carrot juice could coagulate pectin solutions into a calcium pectate jelly.

Muntz and Lainé have extended this study to grapes, grape juice and wines. In this case, the pectose can be solubilised by the action of acids with heat; these workers have studied the changes in pectose and pectin during maturing and fermentation, and have sought relationships between pectins and gums, a group of chemical compounds shown by Pasteur to be present in wines, and later studied by Béchamp, Chancel and Maumené.

At a later date, Bourquelot and Hérissey continued pectin studies, but the greater part of the work has been carried out in Germany and America in connection with the search for commercial materials for jelly-making using apple pomace, citrus wastes and cane sugar bagasse as raw materials.

If 96% alcohol be added to apple juice or cider until the iquor contains 80% alcohol, the precipitate produced contains pectic substances together with a number of impurities. Crystalline salts can be separated by dialysis after solution of the solid phase in warm water. Re-precipitation by alcohol will produce a substance which still retains some mineral materials, but if these are estimated and subtracted from the dry weight of the total precipitate, the result will represent pectin alone. It has been noted that such a purified precipitate is coloured, and that it contains in an adsorbed state many other colloidal compounds, colouring materials and tannins. It was also thought that certain mineral elements entered into the integral composition of the pectin molecule.

Sémichon suggested omitting the dialysis which took 48 hours for its completion, during which period there was always the possibility of alteration in the composition of the pectin. He added 1% hydrochloric acid to the juice before alcohol precipitation, thus retaining the organic and inorganic salts in solution as well as colouring substances and tannins. A whitish or faintly pink precipitate is obtained, with an ash which is no longer alkaline; if, as rarely occurs, some sodium chloride remains, a few drops of perchloric acid will solve the difficulty.

The addition of hydrochloric acid does not affect pectin.

To separate pectin from gums, pectase can be used. This is achieved by the formation of an insoluble calcium salt of pectic acid according to the method of Carré and Haynes. To the pectin solution is added caustic soda for neutralising the natural acidity and to provide a certain predetermined alkalinity in the juice. This solution is left overnight; the solution is acidified with acetic acid and the insoluble salt of pectic acid precipitated with calcium chloride; this is then washed free from chloride, dried and weighed.

Gums can be precipitated from the filtrate by alcohol.

Some recent researches on the constitution of pectin have given some insight into its true composition. Pectins that occur in solution in the juice of fruits exist primarily in the vegetable tissues in an insoluble form called pectose by the French workers; German and American chemists used the terms pectinogen or protopectin. Sucharipa, in examining the original pectic material in citrus peel, concluded that it was a compound of pectin and cellulose, in which the molecule of cellulose was progressively replaced by a methoxyl group (OCH_3).

Glayson, Norris and Schryver, in their studies on apple pomace, have demonstrated that the original insoluble pectin material contains methyl alcohol, an acid (cytopectic acid) and a substance, cytopentane, analogous to the hemicelluloses of Schulze, and soluble in caustic soda.

Von Fellenberg and Ehrlich had previously shown the presence of a methyl ester of pectic acid in apple pomace. According to these authors, pectin in unripe fruit is in an insoluble form with very high molecular weight, i.e. protopectin. During maturation, it changes into pectin which can form colloidal solutions. During fermentation, the same conversion process is concerned with the protopectin which remains in the fruit tissue. The pectin is degraded by a hydrolysing enzyme into methyl alcohol and an acid which Fellenberg called pectic acid, but which is not identical with the acid described by Ehrlich. The methyl alcohol found in spirits distilled from cider and perry is produced by the breakdown of pectin during the alcoholic fermentation.

Tutin has shown, on the other hand, that the action of cold dilute alkalis on pectin is precisely the same as that of pectase. In both cases, pectin produces methyl alcohol and sodium pectate. The presence of acetone and methyl alcohol has been proved in cider; these compounds probably derive from the pectin in the juice during the course of fermentation. These two chemicals can be separated from pectin by the use of decinormal alkali at room temperature. It would seem, therefore, that these two substances enter into the molecule of pectin in the form of etheric groupings.

The fact that the decomposition of pectin leads to the formation of one part of acetone and two parts of methyl alcohol suggests that pectin represents the dimethylisopropenyl ether of pectic acid.

To the cider-maker, the pectins are responsible for contributing a certain 'oiliness' to the juice, and giving it a viscous consistency. All good ciders contain these compounds, generally to the extent of 0·3-0·5%; they confer softness on the flavour of the cider, a character quite distinct from that of the sweetness of added sugar.

It is impossible to indicate the amounts of pectin which should e present in apples to provide a perfect cider, for the amounts ound in the apple itself are quite dissimilar from those found in he ultimate ciders after fermentation. During the processing of he cider, notably during the maceration of the pulp and the larification of the juice, part of the pectin is rendered insoluble nd becomes lost to the juice.

All that can be said in the inexact state of our knowledge is hat pectic substances are necessary constituents of good cider ruit, that they play an important rôle in defecation and sponaneous clarification of juice and ciders during fermentation, nd that they should be present in all normally made ciders.

Besides these pectic compounds, Muntz has found gums and mucilaginous products in apples. Gums are similar in compoition to the pectins and are generally mixtures which contain galactan and araban; they are not crystalline, are colourless, possess no smell, have an insipid taste and a glassy consistency. Apples and ciders can contain up to 0·5% of gums.

Nitrogenous Substances.—Apple pulp contains nitrogen compounds of two types:

(*a*) Albuminoids, more or less complex, partly precipitable by tannin and partly in a soluble form; they are closely related to the peptones and are utilised only to a slight extent by the yeasts. The albuminoids thus pass through into the fermented cider, where they can serve as nutrients for organisms responsible for disorders.

(*b*) Amides, substances much simpler than peptones, not precipitated by tannin, which serve as yeast nutrients during the main fermentation.

Warcollier has shown that the apple contains no nitric nitrogen, but contains traces of ammonia.

Apples contain between 0·3-0·5% of nitrogenous substances; the milling and pressing of the fruit leads to the division of these materials between the juice and the pomace. The juice contains an average of 0·01% total nitrogen, of which about 50% is present as amides. The figures for grapes are between 0·04 and 0·07%; thus, apple is a medium relatively poor in nitrogen, a fact that is of importance from the point of view of the fermentation process.

Mineral Substances.—Apples contain from 0·2-0·4% of mineral substances which are found both in the juice and tissue. This class of compound is composed of phosphates, chlorides and sulphates of potassium, sodium and calcium. The phosphates are of chief significance as they constitute elements of prime importance for the yeasts; in their absence fermentation would be impossible. Potassium is present in greatest amounts in the ash. Iron exists only in small quantities as the very soluble malate salt; in certain conditions, by combining with materials such as tannins, it can be responsible in juices and cider for serious disorders which are difficult to eradicate (darkening of cider).

Other constituents of the ash are aluminium, silicon, magnesium, manganese and boron. Special significance is attached to the presence of calcium, aluminium and manganese; the two former bases have a marked influence on the coagulation of pectic substances; manganese plays a rôle in the oxidation of tannin in the phenomenon of blackening of ciders, since Bertrand has demonstrated that oxidases specifically active in the oxidation of tannins are rich in manganese.

Apples do not contain either nitrates or nitrites, but Warcollier has indicated that fresh pulp exposed to contact with the air for a few minutes contains appreciable amounts of nitrites which are instantaneously formed from a compound which he later showed to be ammonia (Warcollier, *Comptes Rendus de l' Académie des sciences*, 30th March 1914).

Other Constituents.—Apple and other juices also contain several other compounds of which the composition is unknown, or of which the method of their action or the importance of their presence is not yet appreciated. Amongst these compounds are bitter substances (other than tannins), aromatic principles, and glucosides. Vincent and Delachanal have shown the presence of sorbite in apples. Pears can contain up to 0·8%, apples a little less.

Diastases.—Apples contain numerous enzymes, amongst them being amylase, sucrase (which inverts cane sugar into glucose and laevulose, and which is inactivated in the expressed juice); oxidases, as described by Lindet, which cause the oxidation of tannin and the normal deepening of colour in ciders—and sometimes their abnormal colouring to very dark shades; reductase, as studied by Warcollier, which is able to decolourise an xidised tannin, and which has a special importance in mainaining the tannin in juices in solution during the process of naerobic maceration of milled pulp; pectase, which affects the atural or artificial precipitation of pectins, particularly at that tage of cider-making when the juices are subjected to a special larification process.

Aromatic Principles.—Besides the essential oils in the skin of pples, which contribute the aroma and perfume to the fruit, he pulp contains certain odorous materials, possessing a defiite taste, which are responsible for the delicate fruity character f the apple. These compounds appear to their full extent only n the matured apple. They pervade the whole of the pulp and heir presence is readily capable of appreciation by smell on ccount of their volatility.

It is obvious that fruit should not be crushed until the aroma as reached its optimum value, thus ensuring a fully aromatic ider.

These odorous constituents of the apple are chiefly ethers which are formed from the alcohols and volatile acids present n the fruit; these two classes of compounds make their appearance in the fruit during the later stage of maturing. According to Power and Chesnut, the compounds responsible for the characteristic apple aroma are the amyl esters of formic, acetic and caproic, but not valerianic, acids; a little caprylic ether and considerable amounts of acetaldehyde. The relative amounts of the principles vary according to the variety of apple. The same workers have extracted from the apple an essential oil which possesses the odour of fresh apples.

Seeds

The apple seeds are enclosed in the hard laminae of the endocarp.

Endocarp.—This is composed of cells with very thick walls arranged in three or four layers; the inner layer, adjacent to the germ, is formed of hard glossy cells with very thick walls, with practically closed cell space; on account of its constitution, the cells containing the seeds are very solid and rigid. There are usually ten seeds in each apple, two in each of five 'cells', but as fertilisation is nearly always incomplete, the number of seeds is sometimes reduced to zero.

The seed is formed by a series of layers of protective tissue (tegument or episperm) surrounding the kernel.

The kernel consists of the embryo, the cotyledons, and an albumen food reserve.

The kernel represents 45-55% of the weight of the dry seed; the tegument accounts for the remainder.

The kernel contains a fixed oil, a glucoside (amygdalin) and an enzyme (emulsin); the last two, by their interaction, give rise to prussic acid and oil of bitter almonds. Other constituents include gums, albumens, nitrogen-free extractives, celluloses, ash and phosphorus complexes such as lecithin.

Several samples of seeds examined by Warcollier have furnished 0·025% of prussic acid and 0·05% of benzaldehyde.

The seeds taken from ripe apples contain 38-44% moisture. The whole, dry seed may contain 25% of its weight of an oil, colourless, and with a taste which—if fresh—resembles that of beech nuts and poppies.

According to Huber, the apple kernel oil shows resemblances to the oil of sweet almonds from the point of view of its consistency and its behaviour at low temperatures; on the other hand, it differs in the fact that the former has drying properties. Its specific gravity is 0·9237 and its iodine value is 121. The oil develops a rancid taste after a time and imparts this to the cider. The volatile essential oil is thought to be identical with benzaldehyde (oil of bitter almonds); the seeds contain about 0·1% of their weight of this oil.

According to Berjot and Isidore Pierre, in vintage or quality ciders this oil can mask or deteriorate the fine flavour. For their manufacture, therefore, the seeds should not be broken. For second grade or low quality ciders, and in 'seconds', this same oil can mask the characteristic disagreeable taste and consequently can improve such mediocre beverages by contributing some sort of a bouquet.

The essential oil of the seed appears to have a pronounced effect on the quality of distilled spirits prepared from ciders in the fabrication of which the seeds were disintegrated. The eau-de-vie acquires a taste of balsam and contains benzoic acid on maturing.

These considerations lead to the conclusion that in cider-making it is advisable to fracture the seed only when second quality cider or cider for the distillery is being made.

In many large French distilleries, the seeds are not broken, but are recovered from the pomace and sold for nursery work. n those installations which specialise in the preparation of eaux-de-vie, the seeds are always broken to provide additional aroma and bouquet for the distilled liquor.

Warcollier has analysed the ash of the seeds and found that it contains 40% of its weight of phosphoric acid, principally in organic form. The same worker has provided analyses of two samples of seeds from the point of view of their food value for live-stock. The analyses were carried out on seed which had been partly dried; i.e. with a moisture content between 8-10%.

	Apple Seed	*Pear Seed*
Water %	10·2	8·0
Ash %	3·4	3·6
Fat %	24·0	22·3
Nitrogenous material %	29·3	27·3
Cellulose %	18·6	15·6
Nitrogen-free extractives %	14·5	23·2
	100·0	100·0

It is interesting to consider the weight of seeds that is associated with a given weight of apple material.

Berjot gives the figure as 0·555%, or 12.43 lb. per ton of apples. Truelle has found 0·650% of seeds from old-established varieties of fruit from old trees; 0·595% from new varieties and young trees; 0·450% for old-established varieties of pears from old trees. These three percentages can be expressed as the number of seeds per ton of fruit. They are given here:

Old-established varieties of apples from old trees,	116,540 seeds per ton of apples
New varieties of apples from young trees,	144,301 seeds per ton of apples
Old-established varieties of pears from old trees,	115,502 seeds per ton of pears

At the French Pomological Station at Caen, Warcollier had found figures approaching 0·560% (114,016 seeds per ton, each seed having an average weight of 50 mg.).

The seeds existing in apples cannot naturally be collected from the pomace in toto at the time of milling. A certain quantity remains in the pomace; they are separated by sorting machines with inclined frames or of a rotary type, with winnowing or improved ventilating machinery. The recovery of seed in commercial practice is less than that indicated above. Warcollier has observed the results in a factory over a series of years and found that 4½ lb. of seed were obtained per ton of apples, which corresponded to about 16 lb. seed per ton of wet pomace, or 67 lb. per ton of dry pomace. The seed recovered in this way contained no more than 30% moisture; this is due to the fact that the method of separation employed removes a certain amount of moisture during its operation. The weight of seed obtained in Warcollier's experiments from 1 ton of fruit was 4½ lb. with 30% moisture.

Thus it appears that only half the actual number of seeds in the apple can be recovered by commercial means; part of the remainder is destroyed in the milling process, part is left in the pomace.

Glucosides

Jacquemin has stated that the leaves, at various periods of the development of the apple, are the scene of an elaboration of materials which the plant utilises for the growth of other parts, such as the fruit itself. The black currant fruit, for example, can acquire at the time of maturity a characteristic flavour due to the development of a similar flavour which can also be identified in the leaves.

The leaves of the apple tree have no smell, nor can any aroma be noticed if the leaves are crumpled between the fingers or broken in a mortar. But if the leaves are immersed in a 10-15% sugar solution inoculated with a yeast culture, an apple aroma is noticed when the fermentation becomes active. It would seem that the yeast secretes an enzyme which decomposes the glucoside, or some other principles in the leaves, into an aromatic compound and a fermentable sugar. Jacquemin advises that for the purpose of improving the flavour of cider, one should introduce into the fermenting apple juices a syrupy extract of the leaves of apple trees; or to ferment the juice with pure, selected yeasts from vintage blends, produced from varieties of fruits whose leaves have served for the preparation of the inoculum.

In 1928 the theory of Jacquemin still lacked commercial exploitation.

Translator's Addenda

Pectic Substances

The exact nature of the constitution of the various pectic substances has engaged the attention of chemists in England, America, France, Switzerland and Germany during very recent years. Whilst the main distinguishing features of the three types of pectic materials remain substantially as described by Warcollier, many extensions in our knowledge on the basic structure of the various molecules have been achieved. These latest additions to the chemistry of pectin are mainly of importance for the extraction and purification of pectin from apple pomace and the references given below include the most important publications on this subject.

From recent researches, on pectins the following points have been established:

(*a*) Protopectins are loosely associated compounds of pectin and a carbohydrate substance which is probably cellulose. They are insoluble in water and the pectin may be liberated from the cellulose by acid hydrolysis or by the action of an enzyme, protopectinase.

(*b*) Pectins are soluble in water and are broken down in two distinct ways:

(i) Hot acid hydrolysis or the action of the enzyme pectinase results in the formation of the methyl ester of galacturonic acid, a soluble material which on demethylation produces galacturonic acid.

(ii) Cold acid hydrolysis or the action of the enzyme pectase demethylates pectins into pectic acids and methyl alcohol. Pectic acids are slightly soluble in water and are converted into galacturonic acid by acid hydrolysis or by pectinase.

(*c*) The German workers have shown that the pectin molecule consists of a number of galacturonic acid molecules, associated together in long chains, sometimes to the extent of several hundred, in which case the pectin molecule will have a molecular weight of 200,000 or greater (comparable to that of starch). In such pectins, a varying number of the galacturonic acid molecules will be methoxylated; the removal of these methoxyl groups results in the formation of pectic acid. A considerable number of intermediate stages can occur between complete methoxylation and complete demethoxylation, and these account for the varying analyses of natural pectins and for the variation in their behaviour. The word pectin, therefore, must be regarded as a general name for a number of closely related compounds, rather than a reference to one specific chemical substance with a unique composition and structure.

Vitamins

The views held by Warcollier in 1928 on the value of apples and pears as sources of vitamins of the A, B and C groups have not been substantiated by later research. Apples and pears are not appreciable sources of any of the vitamins of the A and B complexes (9), nor can ciders or perries be expected to show any greater promise of value. In very recent years, however, varieties of apples have been noted in which the ascorbic acid (vitamin C) content has been very much higher than earlier data had indicated. Amongst these varieties are a number of cider apples which, taken from young trees, contained very appreciable amounts of vitamin C. No evidence is available which suggests that the ascorbic acid of the fruit is retained in the expressed juice for more than a few hours, and in the majority of cases, the vitamin is completely lost within a few minutes. Thus, the possibility of cider containing more than traces of ascorbic acid is quite remote as long as the present technique is employed, or until further research has elaborated a method for the retention of the ascorbic acid in the expressed juice. A contribution from the University of Bristol Research Station by Pollard, Kieser and Bryan (10) has, however, a real significance and may be of practical importance in the future. The following Table is reprinted by permission of the Director of the Research Station and the three authors.

TABLE IX.—ASCORBIC ACID CONTENT OF SOME ENGLISH APPLES

Variety	*Type*	*Ascorbic Acid mg./100 g.*
Blenheim - - - -	Dessert	6·3
Cox's Orange - -	„	5·7
Wyken Pippin - -	„	3·7
Laxton's Superb - -	„	5·0
Warner's King - -	Culinary	3·7
Beauty of Kent - -	„	6·5

Variety	*Type*	*Ascorbic Acid mg./100 g.*
Norfolk Beefing - -	Culinary	10·0
Newton Wonder - -	„	10·4
Crawley Beauty - -	„	11·2
Edward VII - -	„	13·6
Bramley's Seedling -	„	18·1
Medaille d'Or - -	Cider (bittersweet)	9·1
Dabinett - - -	„ „	12·8
Tardive Forestier - -	„ „	21·3
Yarlington Mill (a) -	„ „	25·2
„ „ (b) -	„ „	34·1
Reine des Pommes -	„ „	31·4
Chisel Jersey - - -	„ „	34·0
Red Foxwhelp - -	„ (sharp)	14·8

REFERENCES

PECTIN

(1) Cheftel, H., *Utilisation Industrielle des Fruits, Confitures, Marmelades et Gelées*. Etablts. J-J. Carnaud et Forges de Basse-Indre, Bull. No. 7, 1943.
(2) Dreschreider and van dem Driessche, *Food Manufacture*, Feb. 1948, p. 77.
(3) Hinton, C. L., *Fruit Pectins*. Dept. Scientific & Industrial Res., *Food Investigations Special Report* No. 8, 1939.
(4) Pallmann, H. and Deuel, H., *Chimia* 1947, 1, 27-50.
(5) Pallmann, H. and Deuel, H., ibid., 1947, 1, 51-70.
(6) Schneider, G. C. and Fritschi, U., Ber. 1936 (B), 69, 2537-43.
(7) Schneider, G. C. and Fritschi, U., ibid., 1937 (B) 70, 1611-17.
(8) Schneider, G. C. and Bock, H., ibid., 1937 (B), 70, 1617-30.

VITAMINS

(9) Bicknell, F. and Prescott, F., *The Vitamins in Medicine*, pp. 159, 310, 379, 455.
(10) Pollard, A., Kieser, M. E. and Bryan, T., *Ann. Rept. Long Ashton Agric. & Hort. Res. Stn.*, p. 200, 1945.

NITROGENOUS COMPOUNDS

(11) Steuart, D. W., *Chemistry & Industry*, p. 357, Nov. 10, 1945.
(12) Tavernier, J., *Food*, p. 271, XVI, 1947.

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CHAPTER IV

ORGANISATION OF CIDER FACTORIES AND FRUIT SUPPLIES

The siting of a cider factory should not be left to chance. Many factors must be considered in making a correct choice. The factory should be situated in a region notable for its cider orchards, so that the transport of fruit can be undertaken to a large extent by the farmer's own vehicles; in this way, rail transport and more expensive forms of transport can be, to some extent, avoided. The cider factory should also be placed near a railway station and should possess a siding. Large quantities of water must be available (well, spring water or purified river water). It must be possible to dispose of all waste water in a condition conforming with the local bye-laws.

The design, lay-out and function of the buildings must be carefully studied. It is advisable, where possible, to adopt the principle of gravitation, where the processing commences at the top of the factory, each subsequent treatment taking place at a lower level. The separate sections of the factory could be chosen thus: fruit store; preparation of juice; fermentation and clarification of the juice; cider storage; pomace drying.

The premises chosen for the fermentation process should be maintained at a low, constant temperature, either by their natural positioning or by artificial refrigeration.

Should the factory include provision for the concentration of juices and the distillation of eaux-de-vie or neutral alcohols, a special section should be devoted to their manufacture. Such a building must conform to the various legal regulations. The complete unity of function of the various parts of the entire factory should be a matter for careful planning.

Electricity is the most convenient form of power, and each machine should be provided with its own motor. Steam, apart from its use as a source of power, is absolutely indispensable in a cider factory for the sterilisation of casks, vats and machines, the heating of water, various liquids, and the drying of the pomace.

Electric lighting only should be used to avoid danger of explosion or fire or even unpleasant smells which are sometimes caused by other methods of illumination.

In general, the planning and building of a factory should be dictated by the need to keep manual labour and overhead costs to an absolute minimum.

Storage of Apples

The detailed study of apple storage has been elaborated by Warcollier in his book *Le Pommier à cidre*. The subjects considered there included the following: Harvesting; Most suitable time for gathering the crop; Picking of apples by varieties or according to maturity; Storage; Completion of maturation; When is an apple ripe?; Storage of apples in grass orchards or on wicker hurdles in the open air; Temporarily covered stores; Pits; Barns; Sheds; Silos.

For the present purpose, it will suffice to consider briefly the question of storage of fruit at the factory itself.

Apple Stores.—These buildings must be well ventilated, provided with large bays fitted with movable shutters which can be opened or closed at will according to the atmospheric conditions. In large factories mechanical transportation of the apples should be effected.

Warcollier recommends the type of movement of apples as developed at the Établissements Saffrey Frères at Lisieux. A series of stores placed at different levels receive the apples by means of a vertical elevator and horizontal belt conveyors. The fruit is distributed amongst the various stores according to its maturity; the stores are filled mechanically without the direct intervention of any manual workers.

The mechanical removal of apples from the store to the mills is also effected by the use of belt transporters, these being continually fed by workmen by means of shovels. Whilst this form of movement for fruit has many points in its favour, it is of the greatest importance that the conveyors should not bruise, cut or disintegrate the fruit or in any way lessen its keeping qualities in the store.

Unfortunately, these mechanical conveyors are relatively expensive.

Warcollier quotes an interesting experience concerning apple storage which emphasises the care that should be taken to avoid the acquisition by the fruit of extraneous flavours. 'A cider-maker had painted the floor of his fruit store with a tar product only a short time before harvest. The apples became tainted and contributed the bad taste both to the cider and eaux-de-vie. Attempts were made to remove the offending substances. The ciders destined for distillation were treated with isinglass, oil emulsion, potassium permanganate, soda, charcoal, but all with no effect. Fractional distillation was examined, ten separate fractions being taken off the offending liquor. The bad aroma and poor taste was noticeable chiefly in the primary fractions; the last portions of distillate were no longer contaminated in their aroma but they all possessed a bad taste. The eaux-de-vie were also treated in a variety of ways, but nothing that was done effected any amelioration in the aroma and taste of the product.'

The importance of avoiding the use in the store of any substances with an unpleasant and penetrating smell is obvious.

Fruit Bins.—Cider factories which cannot equip themselves with these large stores should make use of special bins. These should be completely closed in on three sides, the open side being covered with cloths in case of frost. The depth of fruit should never exceed 3 ft., especially if the apples are to remain more than 15 days in the store to reach full maturity. [The cemented floor of the store should be sloping, and furnished along its length with shallow trenches, each being supplied with running water to convey the apples to the washing machines and the mills. The heaps of apples are placed on planks running transversely across the channels; the planks are removed progressively, and the fruit falls into the channels and is carried away by the running water.]

The cement channels have a trapezoid section with rounded base; their largest width is 10-12 in. and their depth is 10 in. The slope should be 2½ in. per 10 yards in the straight, but should increase to 3½ in. per 10 yards at corners or where the channels are at all curved. Where the channels are of considerable length, small catch vessels should be excavated in the floor of the channels at regular intervals. These should be cemented and serve as receptacles for stones or other heavy materials at might injure the mill; the stones can be removed by hand om time to time.

About 3 gallons of water are needed for the movement of 0 lb. of apples. In cider factories where a quality product is epending on the purity of its fermentation, the water used in ese channels should never be used more than once. In exceponal cases where water supplies are very limited, the used ater should be treated in a vessel where it can be deprived of eavy particles which sink to the bottom, and of those materials hat float on the surface. This process over a long period can roduce water that will be the source of many types of infection, hich may prove to be extremely deleterious to the ciders unless he apple washer is supplied with large amounts of pure, clean ater to remove any such organisms and adventitious materials.

Silos.—Silos are not acceptable in cider factories except in hose cases where the other types of stores are not feasible. The anger of damage by frost in hard winters is always to be feared. The silos must naturally be covered; this being so, the covered ilos are really nothing more nor less than fruit bins open on all our sides.

The floor should be cemented and sloping, and supplied with hannels which run along the whole length of the silo. For a otal length of 12 ft. the silo should have about 3 ft. depth in ts medial section.

The loss of sugar and soluble substances in the systems of conveying fruit described above are variable, depending on the length of the journey, the temperature of the water, and, above all, on the condition of the apples. If sound apples are being moved, and if the apples remain in the water for less than 5 minutes, the losses are negligible (0·01 % sugar). If the factory deals with bruised, cut and broken apples of over-ripe consistency the losses of sugar can become appreciable.

The above observations on mechanical transport of fruit in the cider factory apply only to apples; that is to say, to fruit with a density a little less than water which results in the fruit floating on the water. Pears are in another category; the fruit is denser than water and will sink in it. The transport of pears by flowing water is not advisable, although on occasion it has been practised in distilleries. For movement of pears in the factory, the use of water should be avoided at all costs.

Apple Varieties

In the preceding volume by Warcollier, it has been pointed out that cider manufacture should be based on a knowledge of the varieties of fruit available for pressing, and a capacity to blend various sorts of apples together to form satisfactory blends. Warcollier has previously dealt with this subject in detail, but a brief recapitulation is given here of the salient features of his earlier contribution.

For blending, it is advisable to mix only fruits of the same maturity. The main classes of fruit available for choice of blends are *sweet*, *bitter* and *acid*. The ideal situation would be to know the names of the fruits, their sources, the nature of the soil where they were harvested, and the situation, i.e. whether exposed to the sun or sheltered from it.

Experimenting with blending is essential so that after many seasons one can establish one or more blends of fruit which will provide quality ciders of long keeping qualities.

Each cider-maker should experiment with small samples made from definite varieties. Only in this way can a knowledge of the possibilities of various blends be built up, and such information will enable him to produce beverages for bottling which will have a special appeal on account of their exceptional quality.

This experimental method is the only one capable of giving good results; its widespread adoption would effect a rapid improvement in quality; one should approach as near as possible to the practice in winemaking of restricting production to a very small number of varieties, two, three or four at the most.

Although the following varieties are French and not widely known elsewhere, the information may prove useful to cider-makers who have some knowledge of French sorts. The undermentioned varieties can, each by itself, provide a quality cider: *Joly rouge*, *Petit-Damelot*, *Saint-Laurent*, *C'huero-Briz*, *C'huero-Guen*, *C'huero-Ru*, *Gagnevin*, *Cartigny*, *Domaine*, *Bisquet*, *Moulin-à-vent*, *Doux-au-Gobet*, *Doux blanc Mollet*, etc.

Certain bitter ciders are excellent, but they are improved by blending with less bitter products. The varieties concerned are: *Mettais*, *Reine-des-Pommes*, *Marin*, *Bel-Ordre*, *Solage-à-Gouet*, *Doux-Veret de la Gravelle*, etc.

As examples of blends of two varieties may be noted the folowing: *Groin d'âne* and *Rouge-Duret; Bisquet* and *Petite-Sorte; outeille* and *Solage-à-Gouet; Petite-Sorte* and *Moulin-à-vent; Gagne-in* and *Gros-Bois; Aufriche* and *Doux-Normandie; Joly rouge* and *imetière*, etc.

In practice, three, four or five varieties can be milled together. actories which deal with extremely large tonnages of fruit can-ot deal with known mixtures or varieties, and consequently annot produce ciders of the highest quality. But these factories hould always produce each year smaller quantities of ciders rom known varieties for bottling. Experience has shown that this should not be impossible. Warcollier notes that various nglish and Swiss factories which he had visited were producing, on a regular basis, ciders made from one or two selected varieties, delivered direct to the factory by the growers. He adds: ‘ Why cannot we obtain in France what cider-makers in other countries can obtain in their own factories without difficulty?’

TRANSLATOR'S ADDENDA

Cider Apple Varieties in England

There is little doubt that the existing cider orchards in England have developed from trees which originally came from France, but through the centuries many local varieties have found favour and in the years 1925-1939 many efforts were made by the University of Bristol Agricultural Research Station at Long Ashton to provide a short list of recommended varieties so that the nurserymen could deal with a much smaller number of varieties than would otherwise be the case. In December 1947, the Cider Advisory Committee of the Research Station issued a short general list of recommended varieties, a supplementary list for local planting and a further table setting out the orchard characters of the various recommended varieties. By permission of the University authorities of Long Ashton, these are given here in view of their importance for future planting programmes.

TABLE X.—RECOMMENDED VARIETIES

GENERAL LIST

Varieties valuable for General Planting

		Cider-Making Season	
Class	*Early* (September to mid-October)	*Mid-Season* (Mid-October to mid-November)	*Late* (After mid-November)
Sweet Varieties		Court Royal Sweet Alford	Sweet Coppin
Bittersweet Varieties	Bulmer's Norman	Tremlett's Bitter Yarlington Mill	Ashton Brown Jersey Dabinett Tardive Forestier
Bittersharp Varieties		Improved Foxwhelp Kingston Black Stoke Red	
Sharp Varieties	Backwell Red	Crimson King	

SUPPLEMENTARY LIST

Varieties valuable for Local Planting

			Cider-Making Season	
Local Areas	*Class*	*Early* (September to mid-October)	*Mid-Season* (Mid-October to mid-November)	*Late* (After mid-November)
Devon	Sweet Varieties	Morgan's Sweet		
	Bittersweet Varieties		Ellis Bitter Kingston Bitter	
	Sharp Varieties		Coleman's Seedling	Langworthy
Gloucester, Hereford, Monmouth & Worcester	Bittersweet Varieties	White Norman	Michelin Brown Snout	Fréquin Audièvre Bedan Reine des Pommes Belle Norman
	Sharp Varieties		Frederick (Monmouth)	
Somerset	Sweet Varieties	Morgan's Sweet		
	Bittersweet Varieties		Red Jersey Hangdown	Dove

APPENDIX

Orchard Characters of the Recommended Varieties

Class	*Variety*	*Blossoming*	*Harvesting*	*Remarks*
Sweet Varieties	[1]Court Royal (*Syn.* Sweet Blenheim)	Mid-season	Early-mid-season	Vigorous—similar to Improved Pound
	Morgan's Sweet	Early	Very early	Vigorous. Good stem builder
	Sweet Alford	Mid-season	Mid-season	Vigorous; not suited to light soils. Susceptible to magnesium deficiency
	Sweet Coppin	Very late	Mid-season-late	Vigorous
Bittersweet Varieties	Ashton Brown Jersey	Mid-season-late	Moderately late	Vigorous
	Bedan	Moderately late	Moderately late	Fairly small tree
	Belle Norman	Mid-season-late	Mid-season	Vigorous
	Brown Snout	Mid-season	Mid-season	Moderately vigorous
	Bulmer's Norman	Mid-season	Early-Mid-season	Vigorous; good stem builder
	Dabinett	Mid-season-late	Mid-season-late	Small tree. Susceptible to potash and magnesium deficiencies. Requires fertile soil.
	Dove	Very late	Late	Moderately vigorous. Prefers fertile soil.
	Ellis Bitter	Moderately late	Mid-season	Moderately vigorous
	Fréquin Audièvre	Late	Late	Moderately vigorous
	Hangdown (*Syn.* Horner's Pocket Apple)	Late	Mid-season	Large tree, tangled head
	Kingston Bitter	Late	Late	Moderately vigorous
	Michelin	Mid-season	Mid-season	Vigorous
	[1]Red Jersey	Late	Mid-season	Moderately vigorous
	Reine des Pommes	Very late	Very late	Moderately vigorous; subject to potash deficiency
	Tardive Forestier	Early-mid-season	Late	Vigorous
	Tremlett's Bitter	Mid-season	Mid-season	Moderately vigorous
	White Norman	Early-mid-season	Early-mid-season	Moderately vigorous
	Yarlington Mill	Mid-season	Late mid-season	Moderately vigorous; Very heavy regular cropper

Class	*Variety*	*Blossoming*	*Harvesting*	*Remarks*
Bittersharp Varieties	[1]Improved Foxwhelp	Mid-season	Early mid-season	Moderately vigorous
	Kingston Black	Mid-season	Mid-season	Recommended for suitable localities only
	Stoke Red	Late	Mid-season	Rather slow in forming head, but ultimately gives 'Umbrella' head of moderate size
Sharp Varieties	Backwell Red	Early	Early	Moderately vigorous
	Coleman's Seedling	Late	Mid-season	Vigorous; assumes drooping habit with cropping
	Crimson King (*Syn.* Bealy Down Pippin; Jackson; King's Favourite)	Mid-season-late	Mid-season-late	Moderately vigorous
	Frederick	Mid-season-late	Mid-season	Moderately vigorous
	Langworth (*Syn.* Wyatt's Seedling; Sour Natural)	Mid-season	Mid-season-late	Moderately vigorous

[1] With these varieties it is particularly important to ensure that the correct variety is secured, since there are other sorts also passing under those names. In cases of doubt, reference should be made to the Research Station, Long Ashton.

Bush Cider Apple Trees

The Long Ashton Research Station has examined over a period of many years the possibility of growing cider apples on bush trees. Although the first work on the subject commenced in 1912, the pace was forced from 1932 on account of the urgent need to increase the production of English cider apples to meet the growing demand for cider. The literature from Long Ashton is voluminous and cannot usefully be condensed here. The full references are given below (1, 2, 3, 4, 5) and the original papers should be consulted by those desirous of acquainting themselves with the details and prospects of this new method of cider apple production. It has been generally agreed that fruit of good vintage quality for cider production can be produced by bush trees, grown under the conditions of these trials. With some varieties, crops of over 5 tons per acre were obtained in the sixth year following planting.

Dominion Varieties

Apples from British Columbia, Nova Scotia and Tasmania were examined at the Long Ashton Research Station with reard to their suitability for cider-making. All the ciders made n the three series suffered, in comparison with English cider, y reason of their low tannin content, but pleasant products vere produced from some varieties. Very brief references to the haracter of the ciders are given here.

Tasmania (6)

Adams Pearmain - Thin, rather dry cider, with a not very pleasant flavour.
Crofton - - - Thin, characterless cider.
Crows Egg - - - Sweet cider, soft and lacking in body.
anny - - - Fair cider.
Five Crowns Pippin - Quite good cider with characteristic flavour.
French crab - - Best cider of the series.
Nonpareil - - - Fair cider.

Nova Scotia (7)

Quaker Beauty - - Clean and quite pleasant.
Baldwin - - - Very brisk and quite pleasant.
Wellington - - - Very acid.
King - - - Rather peculiar flavour; only fair.
Ribston - - - Brisk and pleasant.
Stark - - - Sweet and mild; only fair.
Ben Davis - - - Quite fair; rather insipid.
Nonpareil - - - Clean and pleasant.
Fallawater - - - Rather poor.

British Columbia (8)

Mackintosh - - Sweet, fruity, pleasant flavour.
Rome Beauty - - Quite fair flavour; more character than Mackintosh.
Grimes Golden - - Very fair cider, superior to Rome Beauty.
Winter Banana - - Fair.
Jonathan - - - Very fair cider.
Delicious - - - Quite fair cider, but too sweet.
Staymen - - - Good cider with more body than the rest of the series.
Newtown - - - Quite fair.
Winesap - - - Fair.

Canada (General) (9)

Arengo-Jones has provided some additional data on ciders made from Canadian apples. Mackintosh is singled out for its exceptional 'perfumed' aroma; Ribston cider loses its flavour if more than 1% of alcohol is produced; Stark, Baldwin and Spy are lacking in flavour, but Golden Russet retains an acceptable flavour in the final cider.

REFERENCES

(1) Swarbrick, T., *Ann. Rept. Long Ashton Res. Sta.*, 1941, p. 11.
(2) Swarbrick, T., *ibid.*, 1942, p. 13.
(3) Barker, B. T. P., *ibid.*, 1943, p. 124.
(4) Barker, B. T. P., and Burroughs, L. F., *ibid.*, 1945, p. 170.
(5) Barker, B. T. P., and Burroughs, L. F., *ibid.*, 1945, p. 178.
(6) Barker, B. T. P., and Grove, O., *ibid.*, 1927, p. 119.
(7) Grove, O., *ibid.*, 1930, p. 192.
(8) Grove, O., *ibid.*, 1931, p. 174.
(9) Arengo-Jones, P. W., *Fruit Prod. Jour.*, 20(10): 300-303, 321: 1941.

CHAPTER V

PREPARATION OF THE MILLED PULP

Washing the Fruit

f the apples have been harvested with the greatest care and arious foreign substances removed, it is not necessary to wash em; many careful producers can fabricate excellent cider thout a washing process.

On the other hand, it is necessary to wash all fruit which has een carelessly collected, and to remove mud and earth, rotten ecimens, twigs, pebbles and various organic materials if these re present.

Washing can be very simply operated on a farm provided ere is an adequate quantity of clean, potable water available. he apples are merely immersed in a large vessel, such as a tub, hich is filled with water which is constantly renewed; the fruit ould be gently swirled round, then removed from the vessel nd allowed to drain in wicker baskets or in boxes made with n open construction. The washing need only take a few min- tes for each lot of fruit. Another method of washing small lots f apples is to place them in wicker baskets and plunge these uccessively in a series of vessels full of water.

In all sizeable cider factories, the following procedure can e used. The apples are first of all placed on an open moving elt. The larger and more obvious extraneous objects are re- oved by hand as well as the rotten fruit. In this way only ound fruit falls into the washer. This is composed of an iron ank fitted with a perforated, semi-cylindrical false bottom and horizontal shaft, 15-18 ft. long, which carries a series of pad- les arranged in a screw-wise manner, the shaft rotating in the ank at about 15 revolutions per minute. The apples enter at ne end of the washer and the water flows in a contrary direc- ion. The impurities fall through the false bottom and rest on he bottom of the tank, where a large plug permits of their emoval from time to time. The apples, on leaving the washer, re led to a table of perforated metal on which they are shaken to remove surplus water. From there, the fruit is taken to the mills. Beet or potato washers can also be utilised.

Cider factories use many varieties of washing machines. French types include the Tanvez washer-elevator-mill, and the Vernon machine for washing and removing stones. Washers for pears can also be made. They are seen in use in jelly, marmalade and preserve factories in France. In factories where the apples are stored in bins or sheds, the water channels serve to wash the fruit, and it is merely necessary to direct a jet of water on the apples as they ascend on the elevator.

Criticisms have been directed against the washing process on the grounds that it removes soluble constituents from the fruit, as well as a proportion of the yeasts needed for a successful fermentation. Truelle found that dirty apples gave up about 0·1% of their weight of impurities, 0·02% of sugar and equally negligible amounts of acids, tannin and pectic substances. If washing is carried out expeditiously no loss of aroma is to be feared, and the washing water has insufficient time to penetrate into the fruit and dilute the juice (Behrend).

Warcollier showed that sound apples lost, during washing, about 0·05% of sugar, or about 0·5% of the total sugar they contain. This is an insignificant loss. In a 1924 experiment, sound apples were placed in distilled water for 7 hours. The water was concentrated at a low temperature and examined for the principal constituents of the juice. All the tests were negative, and there was no loss of sugar.

With regard to the effect of washing on yeasts, Warcollier has repeatedly observed that rapid washing has no effect on the commencement and continuance of fermentation or on the quality of the cider. It can be said that a somewhat prolonged washing treatment has some value in cases where excessively quick fermentations are anticipated; some form of control has thus been obtained in ciders made in September and October.

These findings have been substantiated by Behrend, who carried out a series of experiments in which various lots of fruit were divided into two, one part only being washed. The yield of juice from the two portions was identical, fermentation proceeded with equal vigour, the chemical analysis of the ciders and perries showed only minute differences for dry extract, alcohol and fixed and volatile acidities. Müller-Thurgau and

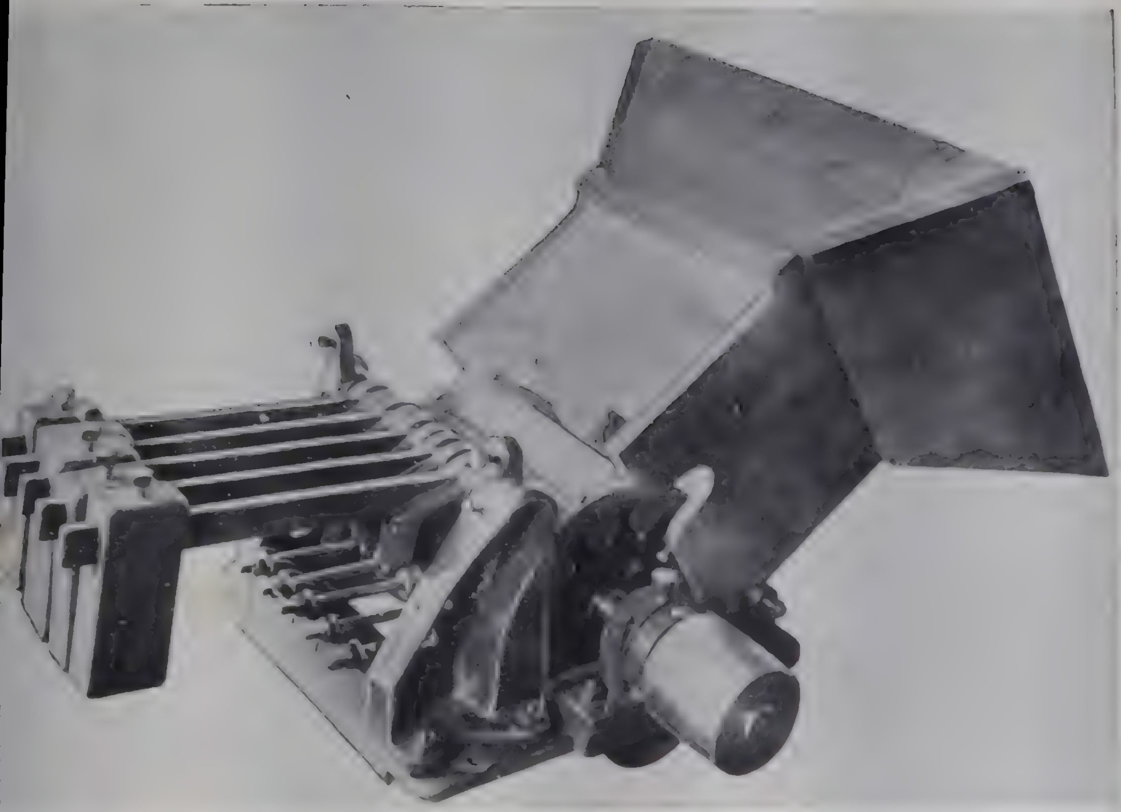

Fig. V. Stowe High Speed Ball Bearing Apple Grater Mill

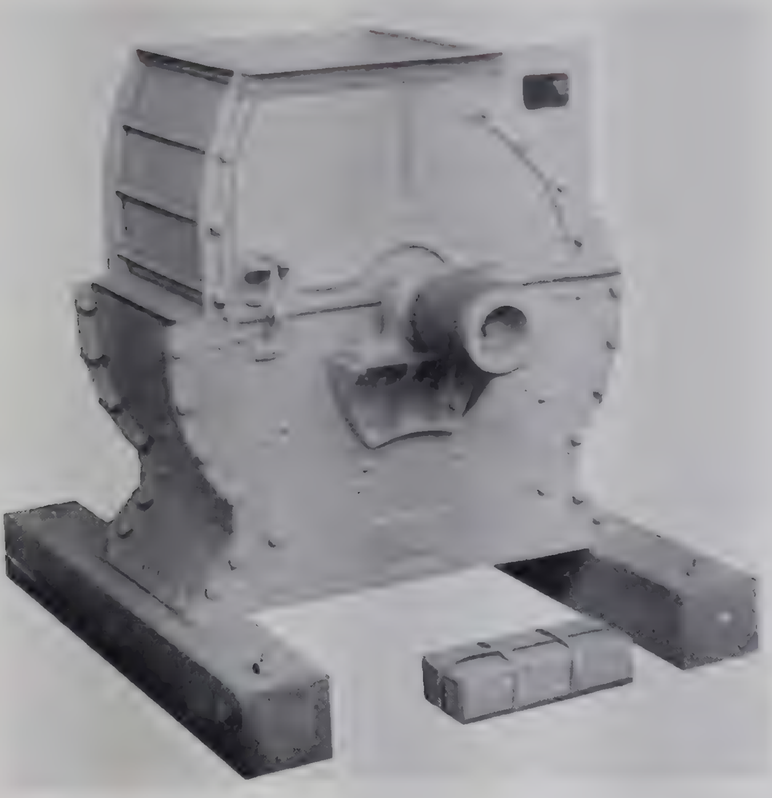

Fig. VI. Miracle Hammer Type Mill

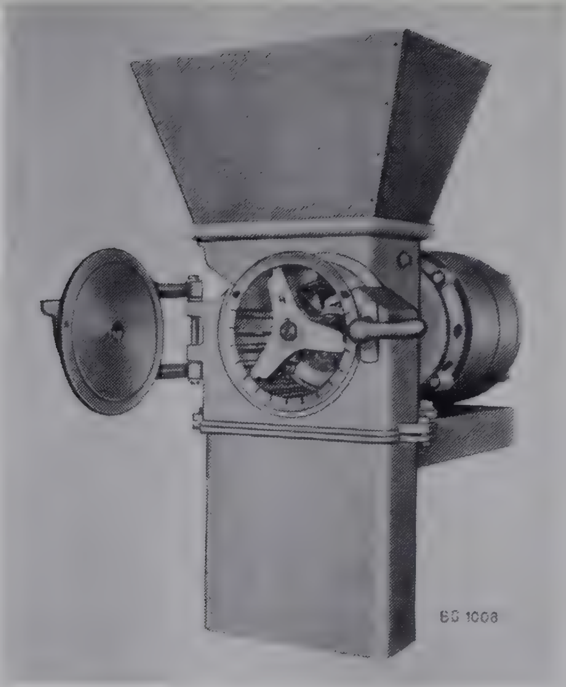

Fig. VII. Swiss Bücher-Guyer Mill

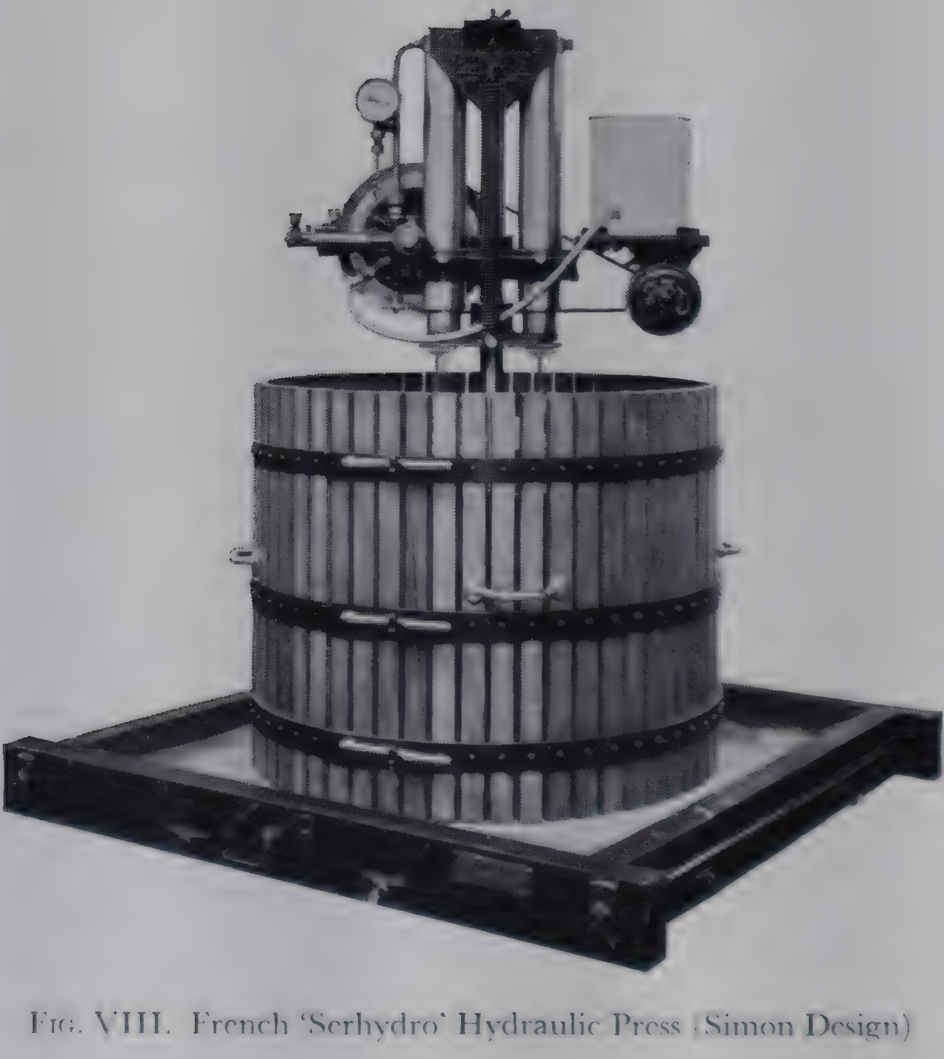

Fig. VIII. French 'Serhydro' Hydraulic Press (Simon Design)

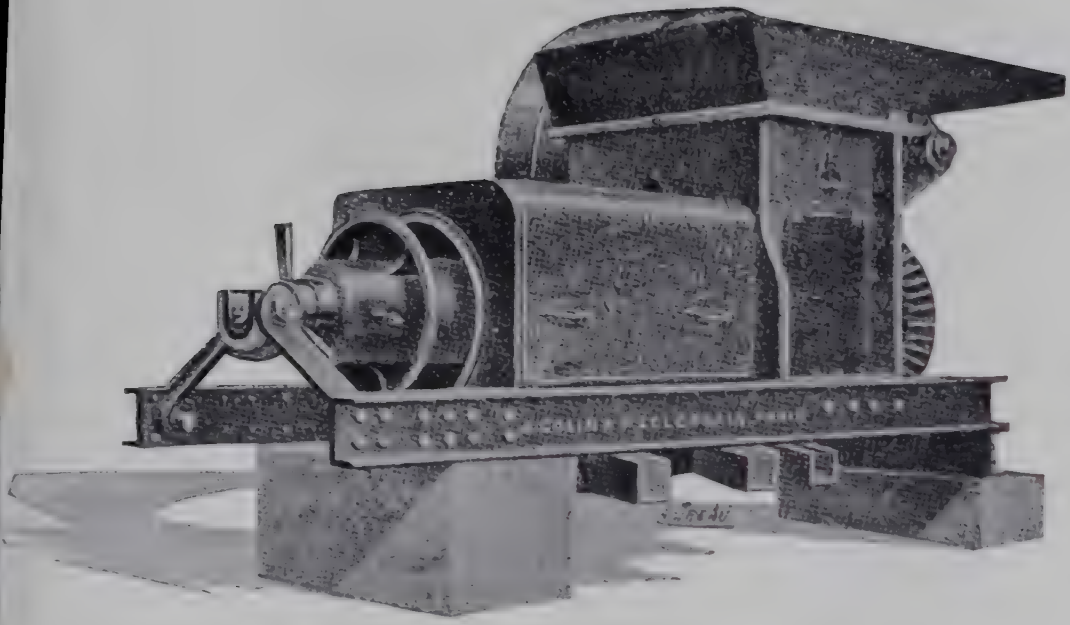

Fig. IX. French 'Colin' Continuous Press

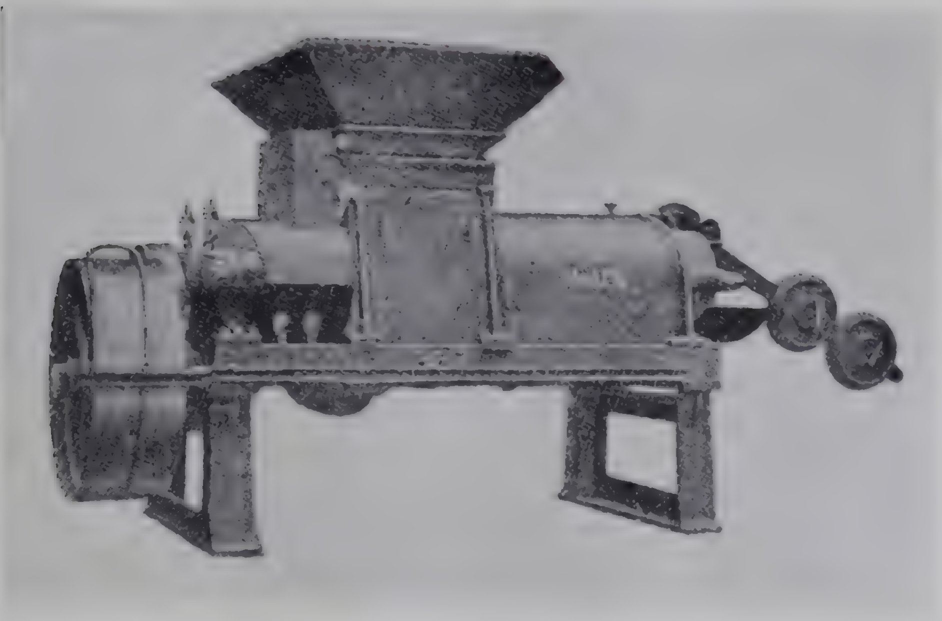

Fig. XII. French Continuous Press (Oberlin Type)

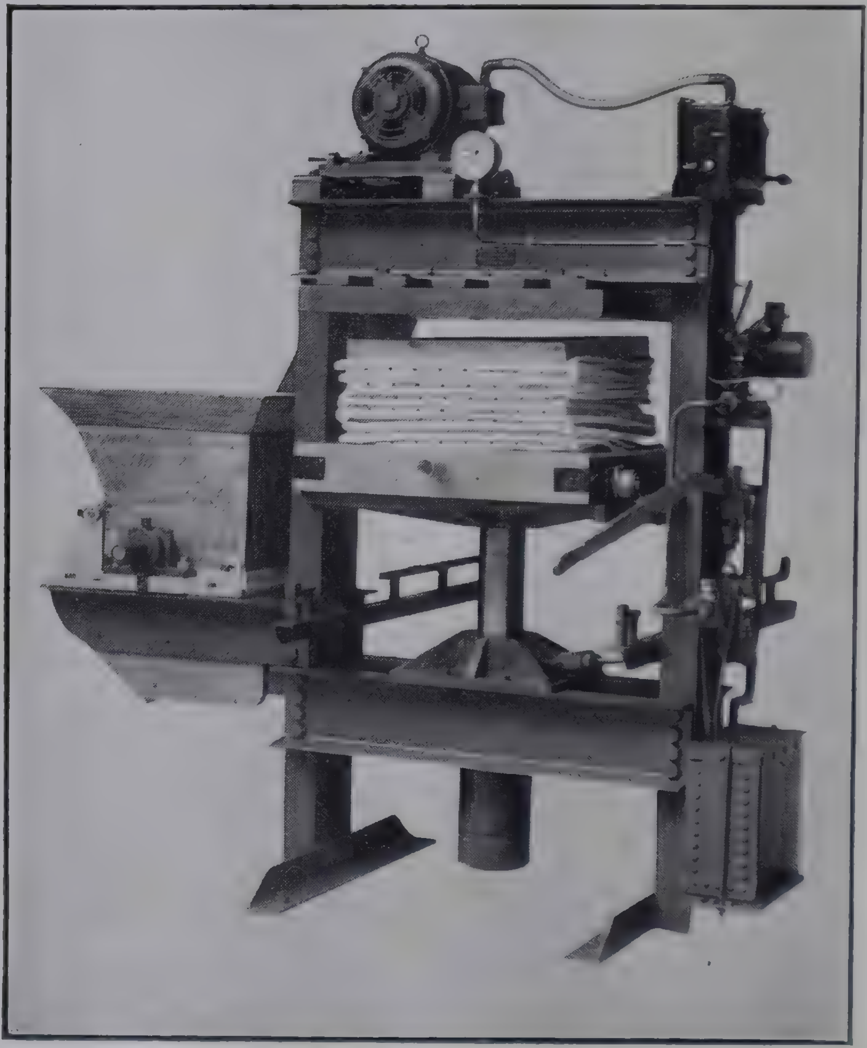

Fig. XIII. Stowe 30-ton Mill and Press

ervalder undertook a most careful washing of fruit, and
nd that this did not eliminate all bacteria from the surface
he fruit. Many bacteria are incrusted on the fruit and do not
n access to the juice until later in the processing; the impor-
nce of this will be seen when spontaneous clarification is con-
ered, for this process is responsible for the elimination of
ese organisms from the juice.

Hence, washing of the fruit is to be recommended, both
cause it removes many impurities from the apples, and be-
use the washing effects a microbiological purification of the
ders.

Quality of Water for Washing.—Water should be as pure as
ssible, free from dangerous organisms of all types. In short,
e water should be potable. If such water is not available, the
isting supplies should be purified and sterilised by the addi-
on of hypochlorites. Care should be taken that the water does
ot contain more than 1 mg. free chlorine per litre (1 p.p.m.).
small a quantity of chlorine will disappear during the wash-
g treatment.

At Caen, Warcollier has obtained excellent results by washing
e fruit in water treated with calcium hypochlorite at 0·04%
rength (recommended by Alliot and Gimel), finally rinsing
e apples with clean water. Warcollier also recommends the
erilisation of water by ultra-violet light or by ozone, but such
eatments are expensive.

Milling the Fruit

Whilst the apples should be ground in such a manner that
e greatest possible number of cells are disrupted, it is impor-
nt that the resultant material should not possess a pasty or
nealy' consistency, a condition causing difficulties in the
ressing operation and affording juices which are viscous and
hich clarify abnormally. These two conflicting conditions are
ot easy to reconcile. The consistency of the apple tissue varies
ontinuously as it approaches full maturity. The type of mill
hich will give optimum results with one variety of apple at a
iven maturity will give a less effective disintegration when used
ith less or more mature fruit. It is especially difficult correctly
mill over-ripe fruit in which the tissue has softened on account
f changes in the pectin compounds in the apples.

Wood or Stone Mills.—These machines were among the first appliances for crushing apples. They were composed of one or two wooden or granite rollers, which rotated in a circular granite trough in which the fruit was placed. A horse was used for motive power (Fig. III)[1], and several complete revolutions of the roller were necessary to achieve fine disintegration of the fruit tissues. Granite mills tended to smash practically all the seeds, whilst wooden rollers had little effect in this respect. The stone mill was almost entirely a farm cider-making appliance, and on account of its cumbersome lay-out, and the constant supervision needed for its operation, this type of crusher has now become practically obsolete. The arguments which claimed that the machines gave a pulp with too fine a division of tissue were, in Warcollier's view, not substantiated. The most important criticism of the old stone mill was that the pulp was exposed to the air for protracted periods; and, again, that the cleaning of the rollers and trough was almost impossible, the apparatus thus becoming a continuous source of infection.

The stone mill era has now been replaced by the age of mechanical crushing or grinding machines. The requirements for these machines are that they should provide a homogeneous pulp of the required fineness of division; that they should be mechanically robust, easy to clean, and be designed in such a way that stones or pebbles cannot damage their moving parts.

Three classes of mills have been developed: gear type mills, roller mills and cylindrical mills.

Gear Mills.—These are composed of two cylinders revolving in opposite directions, the apples being crushed between their teeth. The fineness of division of the pulp can be adjusted by altering the distance between the centres of the two cones. Only one cone is directly activated; its movement is communicated to the other by the interlocking of their teeth. A system of springs enables stones and other hard bodies to be diverted from the mill.

Many types of these mills exist in France; amongst these may be named the Garnier, Lacroix, Savary and Tanvez.

Stone Roller Mills.—In these machines, the fruit is passed between two stone or granite rollers which are often slightly ooved, and the distance between which can be adjusted. ometimes the apples are cut into quarters before being fed to e rollers; often the two rollers rotate at differing speeds and is provides a more perfect disintegration of the cells. Stone oller mills were widely used in Germany and Switzerland (i.e. auschenbach mill).

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[1] Fig. III, from a photograph by Sidney Pitcher, is reproduced by permission of the Publishers of *Gloucestershire Countryside.*

Excentric Vane Mills.—This type of mill was popular at one me but is now replaced by the power-driven grater types of achine. A cylinder was fitted in the lower portion of a large ooden or metal hopper. The cylinder rotated in a counter-lockwise direction, and the fruit was crushed against a concave rface, which was hinged and held in position by a set of prings. The cylinder was fitted with several sets of projecting eeth which were connected to a central axle which rotated ccentrically. The teeth extended to their greatest extent when hey arrived at a vertical position and then were drawn into the uter cylinder as the rotation continued in a counter-clockwise irection.

The above types of mills were operated by manual labour, y a horse, or by electricity, but the motor driven types are now ractically universal.

Grater Mills.—These are widely used in the larger factories. The fineness of division of the pulp can be adjusted, and provision is made to remove stones or hard materials which have ccidentally gained access to the fruit. The rotating cylinder is urnished with sets of serrated steel knife edges, about 10 inches ong; the speed of rotation is 600-4000 r.p.m. Grater mills often provide more juice in the pressing operation than ordinary rushing mills. The prior removal of stones must be carried out with the greatest care if damage to the knives is to be avoided. The grater mill may break the seeds in some circumstances, which is a disadvantage if fine ciders are being made.

Attention should constantly be paid to the state of division of the pulp during the milling operation. The finer the pulp, he higher will be the yield of juice. At the end of each day's milling, the mills should be washed with copious supplies of water to remove all fragments of pulp. Such treatment will avoid excessive attack on the metal surfaces by the fruit acids, the formation of soluble salts of iron, and the discolouration of the juice by the solution of iron and its interaction with the tannins.

TRANSLATOR'S ADDENDA

Washing of Fruit

In recent years, the larger cider-makers have transported the apples from the silos to the mill by hydraulic action and the troughs or 'canals' are so devised that the water automatically and simultaneously washes and conveys the fruit. Provision is made for the removal of stones and for the final rinsing of the fruit from the dirty water before its actual reception into the mill. Although the distances covered by this conveyor system are generally quite short, instances are known where elaborate arrangements have been made to move the fruit over distances as great as 150 yards. Fruit can be moved from the bottom of extremely large silos by an undercurrent of water but considerable volumes of clean, potable water are needed for this purpose.

A very efficient washing machine has been used in England during the past ten years and has given excellent service. The Watts-Adlam apple washer (Fig. IV) is composed of two sections, in the first of which the fruit is freed from dirt, leaves, twigs and other adventitious material. In the second tank the apples are rinsed in clean water and adhering moisture is removed by allowing the fruit to roll over a grid before entering the elevator to the mill. Commercial machines have an input of up to 4 tons per hour.

Milling

The most popular mill in use is the grater type (Fig. V). Several improvements in design and composition of the metal from which it is fabricated have been introduced in recent years. Stainless steel barrels and knives are very recent improvements and contribute to the sterility and cleanliness of the milling process.

Some factories, especially in America, prefer the use of the hammer type mill (Fig. VI) in which the apples are virtually pulverised by heavy metal 'maces' loosely hinged to a barrel rotating at high speed. The fineness of disintegration can be varied at will by forcing the pulp through a perforated plate with suitable sized apertures. The Schwarz comminutor is reputed to achieve a fineness of division in the pulp greater than that of other mills, but it has not been stated whether s goes beyond the stage at which increased yields of juice e obtainable.

The Bucher-Guyer mill, of Swiss origin (Fig. VII), is now ing made in England under licence by H. Beare & Sons of ewton Abbot. This will deliver a pulp of extremely fine con- tency from which the juice is readily expressed by the normal ocedures. The whole apples are carried by positive feed (simi- r to that of a meat mincer) to the rotor which beats the crushed asses of fruit against a set of horizontal knives. The finely illed pulp is ejected through a series of narrow slit-like open- gs adjacent to the stainless steel reversible knives.

CHAPTER VI

MACERATION OF THE FRESH PULP

One of the common practices of cider-making involves leaving the milled apple pulp in contact with the air for 12-24 hours. Shallow vats with large superficial area are used for this purpose, and some makers, to increase the effectiveness of the process, agitate the pulp to incorporate larger quantities of air. The advocates of this process claim that it results in an increased colour, a greater yield of juice, a more intense aroma, and that, in general, the process provides ciders of a high quality. The opponents, however, insist that the maceration of the pulp provokes acetification, lowers the tannin content in the expressed juice, contributes a disagreeable aroma, and, finally, leads sometimes to an excessive colouration, sometimes to an almost complete decolouration of the final ciders.

This subject has been exhaustively studied in France by a number of cider chemists. Durel showed that an aerobic maceration of 30-48 hours causes a practically complete decolouration of the juice and a loss of about 70% of tannin.

Pic, in a study of maceration during 14, 16 and 24 hours, distinguished between the effect of the process on various constituents in the pulp. Whereas the sugar, acid and pectic substances were unaffected, the tannin was removed to the extent of 50-60%.

Séguin and Pailheret operated maceration processes of 36 hours with and without agitation of the pulp. Their findings are enumerated here:

(i) Maceration of the pulp in contact with air increases the yield of juice, the sugar, acid, pectic and ash contents, but reduces the tannin content in the juice by 30%.

(ii) If the pulps are exposed to excessive contact with air, the tannin may almost entirely disappear and the juice become practically colourless.

The maceration of fresh pulp during 24 hours, with or with-t agitation, has been examined by Truelle. He has indicated s results in the following terms:

(i) Yield of juice and colour of pulp increase or decrease ccording to the nature of the fruit under examination.

(ii) The aroma appears to diminish during the vatting rocess.

(iii) The specific gravity, invert sugar and pectic substances ncrease.

(iv) Sucrose, total sugar, tannin and acids decrease.

(v) The loss of tannin may be 80% in the normal process, nd up to 96% in an agitated pulp.

Truelle advises against the practice of maceration, whether f simple type or involving agitation, if a clear, well-coloured, ure cider is desired.

Warcollier, however, has come to quite a different conclusion. n his view, maceration is always a necessity; the pulp from the rusher or mill should never be pressed immediately, but *a aceration should be conducted after due consideration has been given to he nature of the fruit.* Before the actual operation of a successful maceration can be understood it is essential that the theoretical ackground on which it is based should be thoroughly appreciated. Warcollier is responsible for the following three-fold analysis and the practical exposé which succeeds the theoretical treatment of the subject.

(i) *Maceration of apple pulp in contact with air*

During the course of the maceration the broken tissues progressively soften; a proportion of the cells die and their cell fluids are released into the surrounding liquid. It is therefore quite easy to see that a pulp in this condition, when ultimately subjected to pressure, will give more juice, sugar and pectic substances. Actually, the increased yield is not appreciable except in the case of pectins; these compounds reside in the actual cell walls of the tissue and the maceration process facilitates their removal from the softened material.

Simultaneously with the solution in the juice of the principal biochemical constituents of the fruit, other important changes also take place. The apple tannins, having no colour at the precise moment of milling, immediately become brown when the pulp is exposed to the air. It is known that this colouration of the tannin and consequent browning of the pulp is due to the oxidation of the tannin through the agency of an oxidase discovered and studied by Lindet.

If the apples contain relatively high amounts of oxidase, but a low acidity, the oxidation will be rapid. The pulp will quickly become brown, the oxidised and coloured form of tannin will be removed from solution and precipitated on the pulp. The juice will then retain only traces of tannin and will itself be practically devoid of colour; such a juice will yield ciders which are low in tannin and colour.

On the other hand, if the apples contain little oxidase material, and if the acidity is high, the oxidation of the tannin will be retarded; the pulp will stand for a longer period in contact with the air without becoming coloured and ciders produced in these circumstances should be well coloured and contain the necessary tannin content.

These considerations indicate that it is possible, according to the variety of the fruit, its maturity and condition, to produce by this means ciders that are pale or normally coloured, and ciders with low or normal tannin contents. Thus, according to the variety or mixture of fruit, the cider-maker should in one case avoid the possibility of any air contact with his pulp, but in other cases he can leave the pulp in the presence of air with absolute impunity.

As a general rule, fruit which acquires a dark brown colour immediately after being milled should never be macerated in contact with air; fruit in which the browning is slow can safely undergo this process.

The aerobic maceration process, carried out in large vats suitably designed to provide a large superficial area, can therefore be used to produce rich, fully coloured, astringent ciders, but its operation is undoubtedly difficult. The ideal process is actually that which occurs when apples are crushed in the old-fashioned stone mill, but under the guidance of an experienced operator the maceration process can give excellent results.

This process offers one further advantage. In studies on the action of tannin (in the oxidised and coloured state) on the pectins in the juice, Warcollier has established that the pectin-tannin complex passes much more easily into the flocculent state than the colourless pectin provided by an anaerobic macer-

on. That is to say, the pulp must not be handled too quickly
the juice is to undergo a sound clarification and provide a
ear cider. It will be necessary, after milling, to macerate the
lp, arranging for some contact with air, albeit of very moder-
e proportions, so that a well-coloured juice is later obtained
om the press, indicating that one has avoided the loss of ex-
ssive amounts of tannin or pectase enzyme in the preparation.
Varcollier, Contribution to the Study of Cider-Making, Con-
ès pomologique de Rennes—*Bulletin Association française pomo-*
gique, 1926).

Finally, Warcollier was able to establish that the pectin-
anin complex possesses the property, as it passes into the floc-
ulent state, of precipitating a proportion of the nitrogenous
ompounds in the juice. This phenomenon leads to the pro-
uction of juices that are low in nitrogen, and which ferment
owly and over a long period and, eventually, provide naturally
weet ciders. The excessive oxidation caused by agitation of the
ulp should be avoided, for there is a serious loss of tannin and
olour caused by such a procedure. The pectase enzyme, so
ecessary for the spontaneous clarification of the juice, will be
xed on the pulp instead of remaining partly in solution in the
uice, where it is essential for the coagulation of the pectic sub-
tances. The lack of pectase leads to bad clarification of the
uice and pale ciders low in tannin.

(ii) *Maceration of apple pulp in the absence of air*

Warcollier has shown in his own studies that these operations
arried out without air contact cause no loss of tannin. On the
ther hand, there is a definite gain in all the soluble constituents
f the juice, particularly in the pectic substances, and an overall
ncrease in yield of juice from the later pressing procedure.
urther, it has been established by his work that the pectins,
vhich are present in considerable quantities in the pulp, are
ot by any means completely precipitated during the fermen-
ation, and that the finished ciders, clear and of normal colour,
ften contain more than 1% of pectic materials. The presence
n fermented ciders of stable pectic substances had not been
oted previously to the work of Warcollier and the point is of
ome significance.

Maceration in the absence of air is understood to imply the use of barrels or half-barrels, into which the pulp is gently filled and in which the surface area is restricted so that the browning of the tissue occurs only to a depth of one or two inches.

During a maceration of this type, a considerable proportion of the pectase and pectic substances pass into the juice. These conditions facilitate the later precipitation of a part of the pectins, thus providing an effective clearing of the juice and the formation of a brown head, which is always a sign of satisfactory clarification. For this reason, it is appropriate to make use of this process for varieties where clarification is known to be difficult; conversely, it is of little use for bitter sorts of apples, the tannins having the effect of inhibiting both the precipitation of pectins and the consequent clarification.

This type of process is not indispensable for fruits where the pectic constituents are on the point of precipitation, or for thick, viscous juices which are typical of very late season fruit which may have been stored for some time. It is more suitable for early season fruit which often presents difficulties in later processing through lack of sufficient clarification in the juice.

(iii) *Reduction (decolouration) of oxidised forms of tannin*

Warcollier has shown that the pulp from milled apples which has become coloured due to access of air can lose this colour when further air contact is prevented. This is due to a reductase system which reduces the coloured and oxidised tannin to the colourless normal form of tannin. This procedure can be utilised to effect a partial decolouration of a pulp which has suffered through too long a contact with air.

Thus, the three primary considerations theoretically discussed in the preceding sections lead to the conclusion that according to the fruit being used, it is possible to obtain at will pale or coloured juices, poor or rich in tannins, and possessing special properties which affect their ultimate clarification and rate of fermentation. (Warcollier, Congrès Pomologique Vitré, 1904—*Bulletin Association française pomologique*, 1904, 1st volume.)

Successful Maceration Procedure

It has been established in the preceding sections that there is generally an increased yield of juice as a result of the maceration operation. There is, however, one exception to this generisation. If the pectic substances are enzymatically affected uring the maceration, the pulp will become gelatinous and ill release its juice only with difficulty; the yield will be low nd the juice itself will be poor in pectic compounds, since these ill remain incorporated in the pomace.

(i) *Duration of Maceration*

This process, if carried out in the absence of air, should never e allowed to extend over more than 24 hours. In a further 12 ours the pulp is liable to show signs of fermentation, a loss of roma, and the acquisition of an unpleasant taste. On many casions, 12 hours is a sufficient period.

Maceration in the presence of air must not take more than 2 hours; Warcollier has often obtained the best results as they ffect colour and, later, clarification in a period of 6 hours. Certain low acid varieties (*Joly Rouge*, *Gagnevin*, *Mettais*, etc.), where the oxidation of the tannin occurs rapidly, can be treated or an even shorter period than 6 hours.

These considerations show that it is quite impossible to fix a tandard duration for maceration that would suit all fruits. Day o day experience must guide the cider-maker; he must observe he colouration of his juices and the evidence of good natural clarification in them, evidence which is most clearly shown by he formation of a brown head.

(ii) *Details of Maceration Process*

The process can be carried out in wooden or concrete vats, either plain or provided with some form of lining, and furnished with a false bottom made of wood. A tap should be provided at the bottom of each tank so that the pulp can be drained at the end of the operation. The removal of the juice by draining it from the pulp has a practical importance and value since 10-20% (average 15%) of the weight of pulp in the vat can be removed as juice, representing a considerable saving of time and effort in the pressing operation later.

The vats should be rectangular in shape and about 2 ft. 6 in. to 3 ft. 0 in. in depth, so that the workmen can conveniently remove the pulp to build up a cheese. Moderate contact with air can be ensured by filling such vats only half full, without smoothing or settling down the pulp so that a considerable air contact gives the necessary colouration. A completely full vat enables the operation to be carried out anaerobically.

For cider-makers who deal with complete mixtures of fruit of unknown or indefinite composition, Warcollier advises an anaerobic process with, however, provision for the surface layer to undergo considerable aeration. For single variety ciders, either made individually or as blends, a moderate aeration should be achieved; in fact, one should aim at an exposure to air similar in extent to that in the old stone mill. The maceration should be followed by a light pressing.

The rigid exclusion of air is necessary for the production of ciders which are pale, yet rich in tannin.

As an additional aid to achieve this result, the top layer of pulp can be sprayed with a solution of sulphur dioxide in juice taken from the previous pressing. For each square yard of area, 1 gallon of a 0·1% solution of sulphur dioxide should be used. This procedure protects the pulp and the juice from microbial infection.

TRANSLATOR'S ADDENDA

'*Maceration*'

France is the only country where maceration still remains a process in commercial use (1), for it has become practically obsolete in England, Germany and Switzerland. Its chief use would appear to be for the processing of bittersweet fruit. In France, opinion is now divided as to the efficiency of the maceration procedure. Many large factories have discontinued its use, but on the other hand, an appreciable number of very large concerns still macerate the freshly milled pulp, despite the additional plant, labour and time involved. A visit to Normandy in 1938 brought to light a deep cleavage of opinion amongst French technicians but some of the most up-to-date factories still made extensive provision for the maceration process.

REFERENCE

(1) Charley, V. L. S., *Ann. Rep. Long Ashton Res. Sta.*, 1937, p. 160.

CHAPTER VII

EXTRACTION OF JUICE FROM THE MILLED PULP

THE cider-maker should control each stage of the conversion of apples into cider by every means at his disposal. It is advisable o undertake tests on small samples of apples from each conignment of fruit to determine the specific gravity, the sugar, acid and tannin contents, and the yield of juice from, say, 2 lb. samples. This data will enable certain juices to be corrected mmediately after they have been prepared, by adjusting their acidity or sugar content.

When the most effective mixture of varieties has been estabished for each region or soil type, tables can be drawn up to enable the necessary corrections to be made in each particular case so that satisfactory processing may be maintained. The tables can be based on the analyses of juices and ciders which have been shown to be of the highest quality in vintage years.

The chemical analysis of the juice will also provide the cider-maker with valuable data which will enable him to discover any variations in the products during the processing, and thus to achieve some form of control over the whole of his operations. Certain irregularities in processing can be discovered most easily by following the chemical analysis, and, once known, remedies can be quickly and effectively applied. The chief value of chemical analyses, however, is that their use inculcates a sense of 'method' into the cider-maker and leads him to acquire a scientific outlook and approach to his problems without which he cannot expect to achieve permanent success or to make real progress.

Determination of Specific Gravity

This determination should always be carried out on fresh juice as it runs from the press. The apparatus needed is a hydrometer and some suitable vessel to hold the sample of juice and in which to float the instrument. Determinations can be made before the bulk of the fruit is milled by taking small samples of average apples from the various lots, but this is always open to errors. Every effort should be made to take only average fruit, neglecting the large and the small fruits. The juice can be obtained with a small mill and press capable of dealing with 2-5 lb. of fruit. The milled fruit is placed inside a small press cloth or muslin bag and the juice collected from the opening provided. The juice is filled into the cylinder, into which is placed a thermometer and a hydrometer, graduated from 1·000 to 1·100 at 15°C. After a short time the thermometer is read and the reading noted. The hydrometer is inserted into the juice, and when it has become stationary the gravity is read off from the scale. A correction for temperature is made from the table given below.

TABLE XI.—CORRECTIONS FOR SPECIFIC GRAVITY READINGS TO BE MADE FOR VARIOUS TEMPERATURE DIFFERENCES

Temperature °C.	*Corrections*	*Temperature °C.*	*Corrections*
10	−0·6	26	+2·3
11	−0·5	27	+2·6
12	−0·4	28	+2·8
13	−0·3	29	+3·1
14	−0·2	30	+3·4
15	0	31	+3·7
16	+0·1	32	+4·0
17	+0·3	33	+4·3
18	+0·5	34	+4·6
19	+0·7	35	+5·0
20	+0·9	36	+5·3
21	+1·1	37	+5·7
22	+1·3	38	+6·0
23	+1·6	39	+6·4
24	+1·8	40	+6·8
25	+2·0		

Instead of correcting the reading of gravity taken at temperatures other than 15°C. (or whatever temperature is marked on the hydrometer), the juice can be cooled or warmed to the necessary temperature and the reading obtained directly.

Tables have been prepared giving the relationship existing between the gravity of a juice, percentage of sugar by volume in the juice (i.e. grams sugar per 100 ml. juice), and the alcohol strength of the product obtained from the complete fermentation of the same juice, i.e. when it has been converted into a dry cider.

Table XI shows the corrections to be applied to gravity readings taken at temperatures other than 15°C. (i.e. for a hydrometer graduated at that temperature); Table XII is that evised by Lechartier, established by averaging direct analyses n numerous fruits from Brittany and Normandy; Table XIII has een calculated by Dujardin-Salleron by averaging the values es-ablished on the one hand by Lechartier and Truelle on the other.

ABLE XII.—Relation between Specific Gravity, Sugar and Potential Alcohol Contents of Apple Juices (Lechartier)

Specific Gravity	*Sugar % by Volume*	*Corresponding Alcohol*		*Specific Gravity*	*Sugar % by Volume*	*Corresponding Alcohol*	
		% Volume	*% Weight*			*% Volume*	*% Weight*
1·100	20·7	12·4	10·00	1·058	12·5	7·5	6·02
1·099	20·6	12·4	10·00	1·057	12·3	7·4	5·94
1·098	20·5	12·3	9·91	1·056	12·0	7·2	5·77
1·097	20·4	12·2	9·83	1·055	11·8	7·1	5·69
1·096	20·2	12·1	9·75	1·054	11·7	7·0	5·61
1·095	20·1	12·1	9·75	1·053	11·4	6·8	5·45
1·094	19·9	12·0	9·67	1·052	11·1	6·7	5·37
1·093	19·8	11·9	9·59	1·051	10·9	6·5	5·21
1·092	19·6	11·8	9·51	1·050	10·6	6·4	5·13
1·091	19·5	11·7	9·43	1·049	10·4	6·2	4·96
1·090	19·3	11·6	9·35	1·048	10·2	6·1	4·88
1·089	19·1	11·5	9·27	1·047	10·0	6·0	4·80
1·088	18·8	11·3	9·10	1·046	9·8	5·8	4·64
1·087	18·6	11·2	9·02	1·045	9·5	5·7	4·56
1·086	18·4	11·0	8·86	1·044	9·3	5·6	4·48
1·085	18·2	10·9	8·78	1·043	9·1	5·5	4·40
1·084	18·0	10·8	8·70	1·042	8·8	5·3	4·24
1·083	17·8	10·7	8·61	1·041	8·6	5·2	4·16
1·082	17·5	10·5	8·45	1·040	8·4	5·0	4·00
1·081	17·3	10·4	8·37	1·039	8·2	4·9	3·92
1·080	17·1	10·3	8·28	1·038	8·0	4·8	3·84
1·079	16·9	10·1	8·12	1·037	7·8	4·7	3·76
1·078	16·7	10·0	8·04	1·036	7·6	4·5	3·60
1·077	16·5	9·9	7·96	1·035	7·4	4·4	3·52
1·076	16·3	9·8	7·88	1·034	7·2	4·3	3·44
1·075	16·0	9·6	7·72	1·033	7·0	4·2	3·36
1·074	15·8	9·5	7·64	1·032	6·8	4·1	3·28
1·073	15·6	9·4	7·56	1·031	6·6	4·0	3·20
1·072	15·4	9·2	7·39	1·030	6·3	3·8	3·04
1·071	15·2	9·1	7·31	1·029	6·1	3·7	2·96
1·070	15·0	9·0	7·23	1·028	5·9	3·5	2·80
1·069	14·8	8·9	7·15	1·027	5·7	3·4	2·72
1·068	14·6	8·8	7·07	1·026	5·5	3·3	2·63
1·067	14·4	8·6	6·91	1·025	5·3	3·2	2·55
1·066	14·2	8·5	6·83	1·021	4·5	2·7	2·15
1·065	14·0	8·4	6·75	1·020	4·2	2·5	1·99
1·064	13·8	8·3	6·66	1·015	3·1	1·9	1·51
1·063	13·6	8·2	6·58	1·014	2·9	1·7	1·35
1·062	13·4	8·0	6·42	1·010	2·1	1·3	1·03
1·061	13·1	7·9	6·34	1·007	1·5	0·9	0·71
1·060	12·9	7·7	6·18	1·005	1·0	0·6	0·48
1·059	12·7	7·6	6·10				

TABLE XIII.—SUGAR, POTENTIAL ALCOHOL CONTENT AND SPECIFIC GRAVITY OF APPLE JUICES (DUJARDIN-SALLERON)

Specific Gravity at 15°C.	*Sugar % by Volume*	*Potential Alcohol Content in Dry Cider % Volume*	*Potential Alcohol Content in Dry Cider % Weight*	*Specific Gravity at 15°C.*	*Sugar % by Volume*	*Potential Alcohol Content in Dry Cider % Volume*	*Potential Alcohol Content in Dry Cider % Weight*
1·001	0·025	0·01	0·01	1·035	7·2	4·33	3·46
1·002	0·2	0·12	0·09	1·036	7·4	4·44	3·55
1·003	0·4	0·24	0·19	1·037	7·6	4·60	3·68
1·004	0·7	0·42	0·33	1·038	7·8	4·71	3·77
1·005	1·0	0·60	0·48	1·039	8·0	4·82	3·86
1·006	1·2	0·73	0·58	1·040	8·2	4·94	3·95
1·007	1·45	0·87	0·69	1·041	8·4	5·10	4·08
1·008	1·6	0·97	0·78	1·042	8·65	5·24	4·19
1·009	1·8	1·09	0·86	1·043	8·95	5·43	4·34
1·010	2·05	1·26	1·01	1·044	9·2	5·57	4·45
1·011	2·2	1·34	1·06	1·045	9·45	5·71	4·57
1·012	2·4	1·46	1·16	1·046	9·75	5·84	4·67
1·013	2·6	1·58	1·25	1·047	10·0	6·05	4·84
1·014	2·85	1·70	1·35	1·048	10·2	6·16	4·93
1·015	3·05	1·86	1·48	1·049	10·45	6·30	5·04
1·016	3·2	1·95	1·55	1·050	10·7	6·49	5·19
1·017	3·4	2·07	1·65	1·051	10·95	6·60	5·29
1·018	3·6	2·19	1·74	1·052	11·2	6·79	5·45
1·019	3·8	2·34	1·86	1·053	11·5	6·93	5·56
1·020	4·1	2·47	1·96	1·054	11·75	7·09	5·68
1·021	4·35	2·63	2·09	1·055	11·95	7·24	5·80
1·022	4·4	2·68	2·13	1·056	12·15	7·35	5·89
1·023	4·6	2·80	2·23	1·057	12·4	7·51	6·04
1·024	4·8	2·92	2·32	1·058	12·6	7·62	6·12
1·025	5·15	3·12	2·48	1·059	12·85	7·76	6·23
1·026	5·35	3·23	2·57	1·060	13·1	7·91	6·35
1·027	5·55	3·34	2·66	1·061	13·3	8·06	6·47
1·028	5·75	3·45	2·76	1·062	13·55	8·17	6·55
1·029	5·95	3·61	2·88	1·063	13·75	8·33	6·69
1·030	6·15	3·73	2·98	1·064	13·95	8·45	6·79
1·031	6·4	3·89	3·11	1·065	14·15	8·56	6·87
1·032	6·6	4·0	3·20	1·066	14·35	8·67	6·96
1·033	6·8	4·11	3·29				
1·034	7·0	4·22	3·37				

The hydrometer gives the weight of a litre of juice; that is to say, the total weight of the materials of which it is composed. There are thus some complications in deducing the actual weight of sugar present in a juice from its gravity reading.

The tables can only afford approximate relations between the gravity of a juice and its corresponding sugar content. For any one given gravity, the sugar percentage may vary from the true figure determined by chemical analysis by 1-1·5%.

Another method is available for obtaining the sugar content f a juice from its gravity without using any tables, but this gain is empirical and inexact. Hauchecorne and Power suggest hat the last two figures in the gravity should be multiplied by ·15 and divided by 10. Thus, if the gravity is 1·050, the total ugar content is given as $\frac{50\times 2\cdot 15}{10}=10\cdot 75\%$, whereas Table XII gives 10·6%.

Roger de la Borde has indicated a further method of obaining an approximate estimate for the sugar content based on the gravity reading. The last two figures in the gravity are doubled and increased by 10%, then divided by 10. Thus, for a gravity of 1·050 the sugar content becomes $\frac{(50\times 2)+10}{10}=11\%$.

Calculation of alcohol by volume from the gravity

Three methods can be used:

(*a*) Divide the last two figures of the gravity by 8 and add 0·5%, e.g. if the gravity is 1·056, one obtains 7·5% by volume, whilst the table gives 7·2%.

(*b*) Multiply the last two figures of the gravity by 0·125, which is equivalent to dividing by 8.

(*c*) Multiply the weight of sugar obtained from the tables by 0·06.

The last method gives almost exact results and conforms theoretically to the chemical equation for the breakdown of sugar into alcohol and carbon dioxide which occurs during fermentation. This was established by Pasteur, who showed that a solution of 10% of sugar ferments into a product containing 6% of alcohol by volume (4·8% by weight).

In actual practice, all these methods will give figures which are in excess of the true value; normal fermentations do not produce the theoretical amount of alcohol, and the calculated figures should be reduced by 10% if additional accuracy is required.

Yield of Juice

When the small press is being used to determine the gravity, some idea of yield of pure juice can also be gained. This figure will necessarily be very approximate, for industrial presses will give variable results according to the type and power of the machine. However, these trial figures, treated on a purely relative basis, can give interesting results, which are of special value to the producers of pure ciders of high quality.

Pressing

The pulp obtained either with or without maceration should be pressed hard to release the greatest possible amount of juice. It has been seen that the apple contains from 94-95% of juice, and from 5-6% of insoluble substances which constitute the pomace. In practice it is not possible in one single pressing operation to remove more than 60-75% of the weight of the pulp as juice. A quantity of juice thus remains in the pomace, and this must be removed by maceration with water and re-pressing. These inefficient yields of juice, due to the nature of the apple pulp, indicate why water is used in such a routine manner in the manufacture of cider in France.

Factors involved in the Pressing Operation

Ringelmann has shown that apart from the question of the variety and condition of the apples, the yield of juice depends on the pressure applied, the method of drainage and re-building the pulp, and, lastly, the length of time the pulp is held under pressure. These three factors need separate consideration.

(*a*) *Pressure.*—The yield of juice increases with the pressure applied to the pulp, but there is little point in exceeding 55-70 lb./sq. inch, for the additional juice will not be commensurate with the extra effort applied. The sugar content of the juice increases slightly during the pressing operations; hydraulic presses should furnish juices with slightly more sugar than the ordinary form of press.

(*b*) *Drainage of the Pulp.*—The most effective form of drainage is obtained by dividing the pulp into separate layers, about 6 in. thick, with or without some form of cloth to contain the pulp, and separating each layer from the other by light, open-work racks made of wood or wickerwork.

The use of straw or reed is not advisable. The building up and taking down of such a cheese takes an excessive time; the straw and reed materials are breakable, have only short lives, drain badly, and carry impurities and infections on their surfaces that cause a rapid acetification in the ciders made from uices which have contacted these materials. The sole advantage ossessed by the use of these materials is that the French process f 'bêchage' or 'recoupage' can be employed (this involves the emoval of the outer layers of once pressed pulp and their reressing, by being placed on the top of the cheese). This advanage, however, is of slight importance, compared with the nevitable dangers encountered in its accomplishment.

Circular presses, in which the charge of pulp is contained vithin a cage composed of vertical wooden slats, are used in ssociation with wooden or wicker racks without cloths, and uch machines give very good yields of juice. These presses are specially suitable for smaller bulks of apple material: they can e kept comparatively clean, for no cloths are used; sharp apples re particularly suitable for pressing in circular presses, for hey release their juice relatively easily. For such easily pressed naterials, the cage can be of large area but limited depth. Such resses are standard apparatus in Germany and Switzerland.

(*c*) *Duration of Pressing*.—To ensure a good yield of juice, the ressure should be applied slowly and steadily; the time taken o reach full pressure will vary with the size of the press and he amount of fruit actually contained in the cheese. With halfon presses, a quarter-of-an-hour is sufficient, if the time is ounted from the commencement of the application of pressure and does not include the preliminary period of draining in order to 'settle' the cheese into a more stable and solid erection.

Ringelmann quotes his experience with a battery of seven presses, each holding 12 cwt. The preliminary drainage should occupy 50 minutes; the pressing operation itself should vary between 12 and 24 minutes, and the final drainage take 4 minutes. The yield of juice under such conditions should vary between 58-63% of the weight of fruit.

Installation of Fixed Presses

The foundation of a large farm press should be arranged to be a few inches above ground level. An oak, stone or cement base can be used, but the last sections should be covered with a resistant, lining material. Alongside the press should be established an underground vat, lined with glass tiles and of such a size that the juice from one complete pressing operation can be received there. The juice in the vat must be carefully protected against pollution. The floor should slope away and a suction tube arranged to dip into a small gulley running along the bottom of the vat; in this way, the whole of the juice can be withdrawn and the vat can be efficiently cleaned at the end of each working day.

The floor of the farm building used for the press should be of stone construction and sloped to allow constant washing, and provision should be made to remove efficiently and quickly all dirty water and residues from the processing.

Types of Presses

Very many types of presses are available, but only a few can be discussed here.

In general, the older types of fixed presses were composed of a bed frame carrying a vertical screw from its centre. The pulp to be pressed was placed on the bottom of the press and was built up within a circular frame. The top of the press was made of very thick wooden blocks. Pressure was produced by operating a screw around the central, vertical screw, using a long lever for this purpose.

Electrically operated screw presses have been devised, particularly by Messrs. Simon, and have many advantages for cider-makers who wish to use fixed presses of this description. The manipulation of the press is extremely flexible and the operator can stop and start the machine at will. The same makers have developed an automatic air pressure system which is well known in the French cider-making industry. Fig. VIII represents a new type of press developed since the last War by Messrs. Simon Frères.

Mobile Presses

In very large factories the cheeses are erected on mobile trolleys which can be run on rails to the press. Obviously such a system cannot be used with presses having a central screw, or where the apparatus providing the pressure is attached to the top of the press. Two trolleys are needed for each press of this description. Whilst one trolley is under the press, the workmen are building up a cheese on the other and in this way continuity of operations is achieved.

Hydraulic Presses

This type of press is most widely employed on account of the ery high pressures that can be provided in a relatively short me. However, this should not be allowed to reduce the pressing me too considerably, since the fruit will only release its juice t a certain rate, no matter how great the pressure that is being pplied. For a large hydraulic machine, the pressing operation hould extend over 45 minutes. Several hydraulic presses can e motivated by using an accumulator which increases still urther the economy of time in pressing.

The yield of juice from hydraulic presses may reach 75 or ven 80%.

In the majority of cases, the bed of the press is raised by ydraulic pressure against a fixed superstructure. This does not eem to be logical. Efficiency is lost by so doing, and in more nodern installations the pressure is applied from the top downvards against a fixed foundation. The weight of the ram in this ase is a direct aid to the efficient application of pressure and ot a drawback as in the other type of press.

Speed of Pressing

For the production of ciders of high quality produced from chosen varieties of apples, a slow pressing operation is essential to provide facilities for the juice to oxidise slightly in the air, for the pectin substances to be released from the pulp, and for the oxidised form of tannin to combine with part of the pectin which is present in a flocculent state in the juice. These conditions are necessary to provide a satisfactory defecation, or keeving, with the formation of a brown head, which will be discussed later.

In Warcollier's view, commercial cider factories press the fruit too quickly in view of the above considerations. For really good cider for bottling, the pulp should be subjected to a maceration process, followed by a pressing which should extend over at least 45 minutes.

Great care should be taken in the maintenance of the cider presses. All moving parts should be regularly greased to suppress rusting and to ensure smooth operation. The contact of metallic surfaces with the juice should be avoided. Presses with central screws must be oiled and greased in such a way that the cloths do not become contaminated; or the screw may be lacquered with a material which is resistant to attack from fruit juices and is odourless.

The racks and cloths should be washed each working day in copious supplies of water; at regular intervals, additional treatment with warm water containing sodium bisulphite should be given.

Continuous Presses

The 1928 edition of *La Cidrerie* discussed this subject in the following terms: 'Continuous presses are not yet employed in a routine manner in the cider factories; there is always fear that the juices will be produced with a thick consistency and will contain too much tissue.

'Many types of press have been examined but all of them exhibit some deficiency which is primarily and fundamentally due to the raw material being in a mucilaginous state. The results of present researches are eagerly awaited, for efficient continuous presses would fulfil a most useful purpose in the industry.'

In 1928, continuous presses were well-known in apple distilleries, and were just becoming evident in cider factories also. The results given by these presses in cider-making are not yet satisfactory, but the designing of a completely suitable plant would provide a notable achievement for the cider engineers. The new designs should enable the plant to increase the yield and clarity of juice, reduce the moisture content of the exhausted pomace fed to the drier, and reduce the quantity of lees deposited during the fermentation process.

Until 1928 the yield of juice had been inferior to that of hydraulic presses; the usual figures are between 50-60% of juice, the variation being largely due to the state of the apple pulp fed into the machine. Fruits that form a 'mealy' type of pulp will only give a very poor yield of juice in continuous presses; more economic returns of juice are associated with crisper tissues or higher acidities.

As examples of the various types of continuous presses may be cited those of Colin (constructed by the firm of Lelogeais); Oberlin (made by the firm of Dury); Hanslin and Mabile.

The Colin machine (Figs. IX, X and XI) will be described ere. The operative agencies for exerting the pressure required extract the juice are two screws, A and B, placed end to end, nd which turn in a contrary sense inside a perforated cylinder. his cylinder is open on the top at one end and is surmounted y a moveable hopper into which the apple pulp is fed.

The pulp, taken up by the first screw, is forced forward by e second screw inside the perforated cylinder C, the end of hich is closed by the cone R; juice passes through the perorated sieve and is collected in a water-tight vessel with three ompartments. The pressed residue is released through the pening around the cone R, which is maintained in place by large screw S.

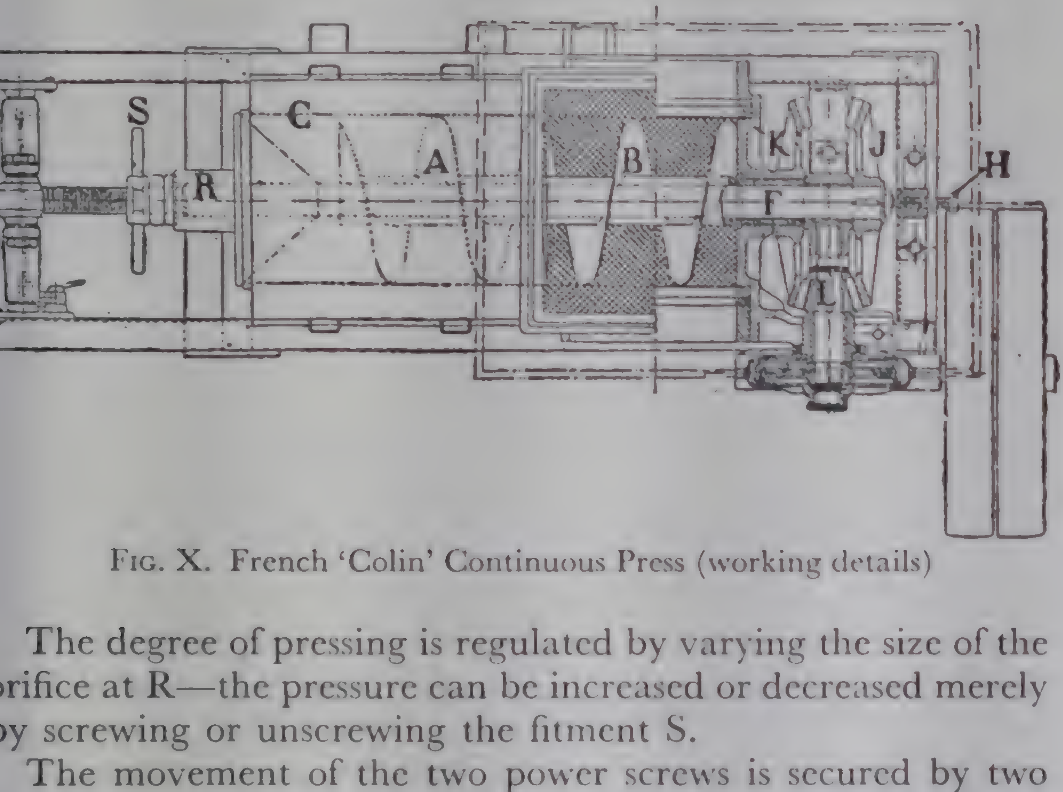

Fig. X. French 'Colin' Continuous Press (working details)

The degree of pressing is regulated by varying the size of the rifice at R—the pressure can be increased or decreased merely y screwing or unscrewing the fitment S.

The movement of the two power screws is secured by two oothed conical gear wheels, K and J; K is engaged by the crew B; whilst J is associated with A through the shaft F. The wo gear wheels K and J are driven by the pinion L, which is ttached to the shaft of the continuous gear device M.

This is enclosed in an oil bath, and the two gear wheels otate at 3 r.p.m. The continuous screws are fabricated from ronze and phosphor-bronze, but the gear wheels are in teel.

This continuous press of the Colin type provides a gentle pressure which can be regulated as required. The design of the two screws and the circular form of the surrounding cylinder avoid the breaking of the seeds.

Another type of machine is that of Oberlin (Fig. XII) and embodies the principle of the Archimedean screw. The machinery consists of twin bronze screws, symmetrically arranged, turning one towards the other at similar speeds. The material to be pressed cannot revolve with the screws, for it is progressively compressed and forced back towards the discharge port; the press does not become choked in the process.

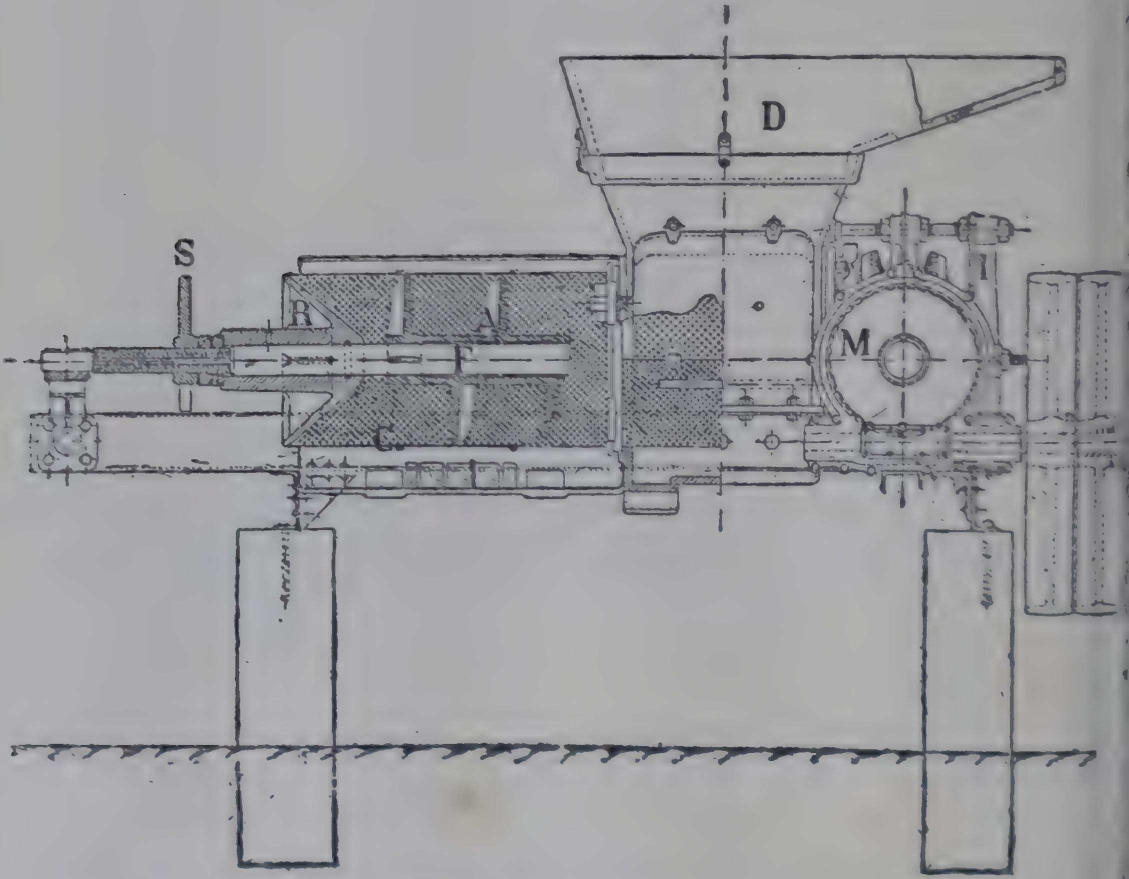

Fig. XI. French 'Colin' Continuous Press (working details)

The screw mechanism can easily be withdrawn from the cylinder. The outer cylinder is composed of thick copper and is reinforced by steel hoops. The juice-receiving vessel is made of copper and comprises several compartments each with a run-off cock. The discharge port carries a counterbalanced lever ich allows the operator to regulate the degree of pressure plied in the machine and hence the dryness of the pomace uing from the delivery port.

This press has been in use in Alsace and Germany and has ven very satisfactory results with sharp fruit. Low acid fruit, owever, does not give an economical yield of juice.

Another type is known as the Hanslin press. This is comosed of an endless canvas belt of very stout construction, which formed into an envelope which holds the pulp. A simple rangement allows the outer seams of the cloth to open to ceive the pulp, and after their reclosure the envelope and its closed tissue is passed through rollers to be pressed. The tissue discharged after the pressing operation, and the continuous elt' is then ready to be re-filled. The whole operation is autoatic; the extent of the pressure applied depends on the speed f the belt. The slower the movement of the belt, and the smaller e amount of pulp being used, the greater will be the extraction f a superior quality of juice.

The pulp should not be too finely milled for this form of ontinuous press.

Trimming the Cheese

The use of a press with a central screw enables the cideraker to increase his yield of juice by carrying out a trimming peration. Using a special knife, a portion of the outside of the heese is removed to the extent of 4-6 in. The head of the press raised and the trimmings are inserted above the cheese. Reressing will afford a further supply of pure juice.

A special mechanism is available for circular presses, but bviously the process is inappropriate for cheeses built up by eans of cloths and racks—in this case the cheese must be aken down, the pomace broken up through a mill, and then e-built into a new cheese and re-pressed. This last practice is ot advisable on account of the excessive manual labour called or, and the extra effort is out of proportion to the additional uice collected. Such a process should be confined entirely to ears of scarcity of fruit, when only pure juice is to be made. etter results are given by sharp apples than by the sweet arieties.

Pomace Maceration with Water

Taking the average value of the juice content of apples as 95%, and the average withdrawal of juice in the pressing operation as between 57-72%, it can be seen that the pomace retains from 23-38% of the original juice in the apples. This residual juice can be extracted by allowing the pomace to macerate with added water for a period of several hours, followed by a repressing of the pulp. The general procedure is to carry out two resoakings with water followed by the appropriate pressing operations, but occasionally a further complete process is added. After the third maceration, i.e. after three resoakings and four pressings, a procedure confined entirely to years of great scarcity of fruit, the pomace will be 'exhausted', and skilled workmanship should provide an ultimate form of pomace which contains only 2-4% of the total initial sugar content of the apple.

With two macerations, and the use of screw presses, using for each process a quantity of water equal to half the weight of the pomace, the loss of sugar amounts to 8-12% of the total initial sugar content of the apples, but this figure can be reduced by the use of hydraulic presses.

When a series of macerations are carried out in the factory, the gravity of the juice provided by each pressing will progressively diminish. The macerates may be fermented singly or after blending, but in either case, the final product will be a dilute cider or '*boisson de pommes*'. On the other hand, the juice obtained from the resoaking process can be used with pure juice from the first pressing to provide the normal market ciders.

As an example of the precise arithmetical significance of the process of maceration with water, the following average case may be cited. The calculations are based on the initial use of 1 ton of apples. It may be taken that the apples contain 19 cwt. of juice of gravity 1·055, which corresponds to 200 gallons of juice.

After a preliminary draining and the initial pressing operation, this ton of apples will yield about 125 gallons of juice of gravity 1·055. Thus, 8 cwt. of pomace remains and retains a further 75 gallons of juice to be extracted. The pomace is macerated with half its weight of water or, better still, with a quantity of water equal to half the weight of juice still remaining in the pomace. In the present example, the quantity of water will between 38-45 gallons; after twelve hours, the pulp is pressed, ving 45-50 gallons of an approximate gravity of 1·030.

Again, 38 gallons of water may be added to the twice-pressed omace and macerated for twelve hours. A third pressing will ovide 47-50 gallons of juice with a gravity of about 1·016. he pomace will by now be exhausted.

As a general rule, once-pressed pomace is soaked with the quor from the preceding second maceration (i.e. with a gra- ty of 1·016) rather than with water.

Following a procedure as outlined above, 225 gallons of total quor are obtained per ton of fruit; only 90-92% of the sugar iginally in the apples has been extracted in the form of juice; e loss is thus between 8-10%.

Power has compared the yields obtained with old-fashioned resses and hydraulic machines. His comments are given here.

(*a*) *Old-fashioned Screw Presses.*—1 cwt. of apples gave 3½ gal- ons of pure juice of gravity 1·055. The pomace was broken up nd moistened with 5½ gallons of juice of gravity 1·016 pro- ided by the third pressing of the preceding operation.

The second pressing yielded 7½ gallons of juice of 1·035 gra- ity. For the second maceration, 5¼ gallons of water were added o the pomace.

The third pressing gave 5½ gallons at a gravity of 1·106. At e conclusion of this series of macerations and pressings, the omace contained 2 oz. sugar per 10 lb. of fruit used. As 10 lb. f fruit contained 20 oz. sugar, it can be seen that the loss of ugar was 12%, based on the original sugar in the apples.

(*b*) *Hydraulic Presses.*—1 cwt. of apples gave 5¾ gallons of uice from the first pressing. The pomace was ground and eated with 5½ gallons of juice of gravity 1·010 from the third ressing of the preceding batch of pulp. This, after maceration, as pressed, yielding 7½ gallons of juice of gravity 1·022. The econd maceration was made with 5¼ gallons of water, and the hird pressing gave 5¼ gallons of juice of gravity 1·010. At this age the pomace contained 0·13 oz. of sugar per lb. of fruit riginally milled. Now, as 1 lb. of fruit contained 1·63 oz. of ugar, the loss in sugar was 8% of the total sugar present in the uit. These figures confirm those given earlier in this section.

Another example of the operation of a maceration process an be cited from the publications of Gallemand, who used two pressings with a hydraulic press. 20 cwt. of apples gave, at their first pressing, 12½ cwt. (133½ gallons) of pure juice of gravity 1·0535, and 7½ cwt. of pomace. This pomace was macerated with 55 gallons of water, which then provided 8¼ cwt. (90 gallons) of juice at 1·030, and 4¼ cwt. of pomace. The twice-pressed pomace retained 11% of the total original sugar and the total juice collected amounted to 223½ gallons of gravity 1·044.

Warcollier, however, has made numerous determinations in cider factories covering a wide variety of processing techniques. A survey of these figures showed that according to the season, the price of apples, the procedure adopted in the factory (i.e. one or two resoakings), the final samples of pomace contained a maximum of 7% of sugar in the fresh pomace (average moisture content from a hydraulic press being 72%); and either 21·7% of sugar in a 'dried' pomace with 13% water, or 25% of sugar calculated on a dry matter basis.

In general, well-conducted and well-equipped factories produce fresh pomace materials with 4-4·2% sugar, or 12·4-13% in the dry pomace as sold.

Warcollier has collected his views on this question of efficiency of extraction in the form of a table which is given below.

	Fresh Pomace 72% moisture	*Dry Pomace 13% moisture*	*Dry Pomace (Moisture-free basis)*
Poor extraction of the pulp - - -	7·0%-sugar	21·7%-sugar	25·0%-sugar
	6·0% ,,	18·1% ,,	21·43% ,,
Fair extraction - -	5·0%- ,,	15·5%- ,,	17·86%- ,,
	4·2% ,,	13·0% ,,	15·00% ,,
Good extraction -	4·0% ,,	12·4% ,,	14·29% ,,
Very good extraction	3·0% ,,	9·3% ,,	10·71% ,,
Excellent extraction -	2·0% ,,	6·2% ,,	7·15% ,,

The dried pomaces from cider factories generally contain more than 10% sugar; very few, however, retain more than 15%. The sugar contents which have been mentioned throughout this examination of the process of maceration with water refer to the combined sugars glucose, laevulose and sucrose.

Whenever it is desired to check up on the loss of sugar in processing, the pomace must be analysed immediately after it has been taken from the press. If this is not done, fermentation will quickly ensue, the sugar will be removed by yeast action d the analysis will not give a true picture of the efficiency of e exhaustion of the pomace.

The quantity of water that should be used for the maceration ocess must be determined after a consideration of the yield pure juice and the type of beverage which is to be made. The mace from juicy apples will need relatively small amounts water and fewer individual macerations will be required; ss juicy apples will provide fresh pomaces which will retain ore juice, and to extract this juice efficiently it will be neces-ry to operate more resoakings and to use more water.

It is normal practice to utilise the liquors from second or ird macerations for soaking the fresh pomace from the first essing of the succeeding batch. Again, these water extracts the pomace are used for addition to fresh pulped fruit, before essing; in which case pure juice ciders cannot be produced. astly, these weaker extracts can be blended with the diluted ice from the first maceration for the production of dilute ders (*boisson de pommes*).

Suppose that a hogshead of cider (50 gallons) is to be pro-uced from 5-5¼ cwt. of fruit. The fruit should be milled and ne pure juice extracted. The pomace is macerated with the ice provided by the second maceration of a former batch, dding such a volume that its weight is approximately equal that of the pomace which is to be macerated. In this way, o gallons of juice will be collected, which will furnish, after rmentation, a cider with 4% alcohol by weight.

The position can be summarised in this form: 1 ton of apples ill provide 134-136 gallons of pure juice which will ferment nto a cider with 4·4-5·6% alcohol by weight; alternatively, ne can produce 223 gallons of a somewhat diluted juice, giving cider with 4% alcohol by weight; or lastly, 334-445 gallons f juice may be provided which will, after fermentation, show n alcoholic strength of 2·39% by weight.

In years when there is a glut of fruit and apples are cheap, nly one, or at the most two, macerations are carried out. very effort is made to produce pure juice ciders, for the sale of ow alcohol products would prove to be very difficult in such ircumstances. On the other hand, in years of shortage, an dditional maceration is included in the factory routine.

In all this processing, it is essential for attention to be paid to the question of obtaining an economic return for any labou expended in recovering residual juice from once-pressed pomace. It is not enough to feel satisfied with the production of a thoroughly exhausted pomace. Attention must be directed also to the overheads and labour costs which have been incurred in so doing.

Practical Details of Maceration with Water

The pomace must be disintegrated to facilitate intimate mixing with the added water and adequate solution of the soluble constituents from the pomace. Cider apple mills should not be used for this purpose, as the passage of pomace through the mill is often difficult and a workman is needed to keep the mill mechanism free from obstruction. Special pomace disintegrators are available for this purpose.

Maceration with added water should proceed for 6-12 hours. Excessive contact with air should be avoided, thus preventing undue oxidation of the tannin, its removal from solution and fixation in the pomace, and also to avoid the acetification o the pulp. The macerate should be quickly pressed after th appropriate interval of time.

When vats with large superficial areas are used for the maceration of pomace with water, the surface of the pulp can b sprayed with a solution of sulphurous acid (½ gallon of 0·1 % aqueous solution per square yard of surface). These data refe to vats with a depth of 2¾-3 ft.

The time necessary for completing the resoaking process ca be reduced to 4-6 hours if the pulp is frequently sprayed o otherwise wetted with the liquor which drains from the pul to the bottom of the vat.

Hot water can be substituted for cold if a quickening in th maceration is desired. The use of hot water provides a juic which will ultimately clarify more efficiently, but the temperature in the pulp during maceration should never exceed 20°C Hot water maceration is particularly suitable for the productio of ciders to be distilled. In some cases where fermentation i the maceration vats is considered to be likely, the re-presse liquors are cooled before being subjected to keeving and fermentation so that clear products can be obtained.

Γhere is, however, one way in which warm water can be ed with impunity. The hot water treatment should be com- ied with the use of sulphur dioxide at a strength sufficient to ovide a maximum content of 0·01% (100 p.p.m.) of sulphur xide in the juice recovered by the resoaking process.

The vats used for the maceration process should be fitted th false bottoms and taps for the collection of the juice. They ıst be suitably made to receive a most thorough washing and be drained completely. Their depth should be between $2\frac{3}{4}$-3 so that the workmen can transfer the pulp conveniently from e tank to the press.

Choice of Water for Maceration

It should be superfluous to insist that the water for macera- on processes should be of good, potable quality. Nothing but solutely pure, clean, potable water, free from organic material a state of decomposition, should be used. One must avoid ater heavily charged with mineral salts or those drawn from e sea or containing salts normally associated with sea water. ne most appropriate supplies of water are clear, colourless d tasteless; they should possess no smell and should be soft d such as would normally be acceptable for the cooking of od. The presence of calcium carbonate, however, is not detri- ental, for this salt encourages the development of a brown ad with consequent spontaneous clarification of the juice and us contributes to the ultimate clarity of the cider.

The water should be potable and as a consequence should ntain no pathogenic organisms. Contrary to the old saying at 'fermentation is a universal purifier', it has never been oved that the organisms which are responsible for various seases such as typhoid fever *cannot* live in cider for a certain terval of time. Various interesting details are available con- rning the viability of the *Bacillus d'Eberth* (typhoid fever ganism) in cider.

Louis Olivier discovered the organism in sea water at Gra- lle (Le Havre) which was used for cider-making purposes, d stated that the fermentation process did not modify in any spect the vitality of the organism when it was introduced into der in the form of spores.

Dr. Vigot, in 1897, concluded that the typhoid bacillus and coliform organisms were destroyed in cider when they were introduced either with the apple or with the water used in maceration.

Bordas and Joulin (1898) took the contrary view, and indicated as a result of their researches that coliform bacteria are not destroyed in cider and can even develop in this medium.

In the same year, Bodin showed that when typhoid bacilli in water were introduced into fermented ciders, the organisms multiplied and remained viable during a certain period. He concluded that low-acid ciders were dangerous to drink during the eight days which followed maceration (i.e. from the time of inoculation with the bacilli).

Bodin and Pailheret continued their investigations in 1902. They found that the bacilli were destroyed whenever the media contained sucrose. However, these experiments were carried out on synthetic media other than apple juices and fermenting ciders, and their results do not appear to have proved that sweet ciders cannot affect the bacilli.

In 1921, at the Apple Conference at Rennes, Dr. Bodin provided a summary of his work on this question.

'(*a*) The typhoid bacillus, on being introduced into cider, is destroyed in 2-18 hours after inoculation.

'(*b*) This destruction of the organism is mainly due to the acidity of the juice; the lethal effect follows as a matter of course in all cases where the acidity is greater than 0·2% malic acid.

'(*c*) In all normal ciders which possess acidities in excess o 0·2% malic acid, the typhoid organisms cannot persist for a longer period than 18 hours.

'If the addition of water is capable of infecting a cider and rendering it dangerous to drink during the twenty-four hour following the moistening of the pomace, then the above fact are not reassuring for cider drinkers; the maker should exer every possible effort to produce an hygienic beverage of th highest quality.'

If potable water is not available, then the supply should b sterilised. A factory should never use any water for any purpos without previously obtaining an analysis showing its chemica and bacteriological condition. To use a supply of water which the composition is unknown is to take grave risks and t compromise the success of the entire process.

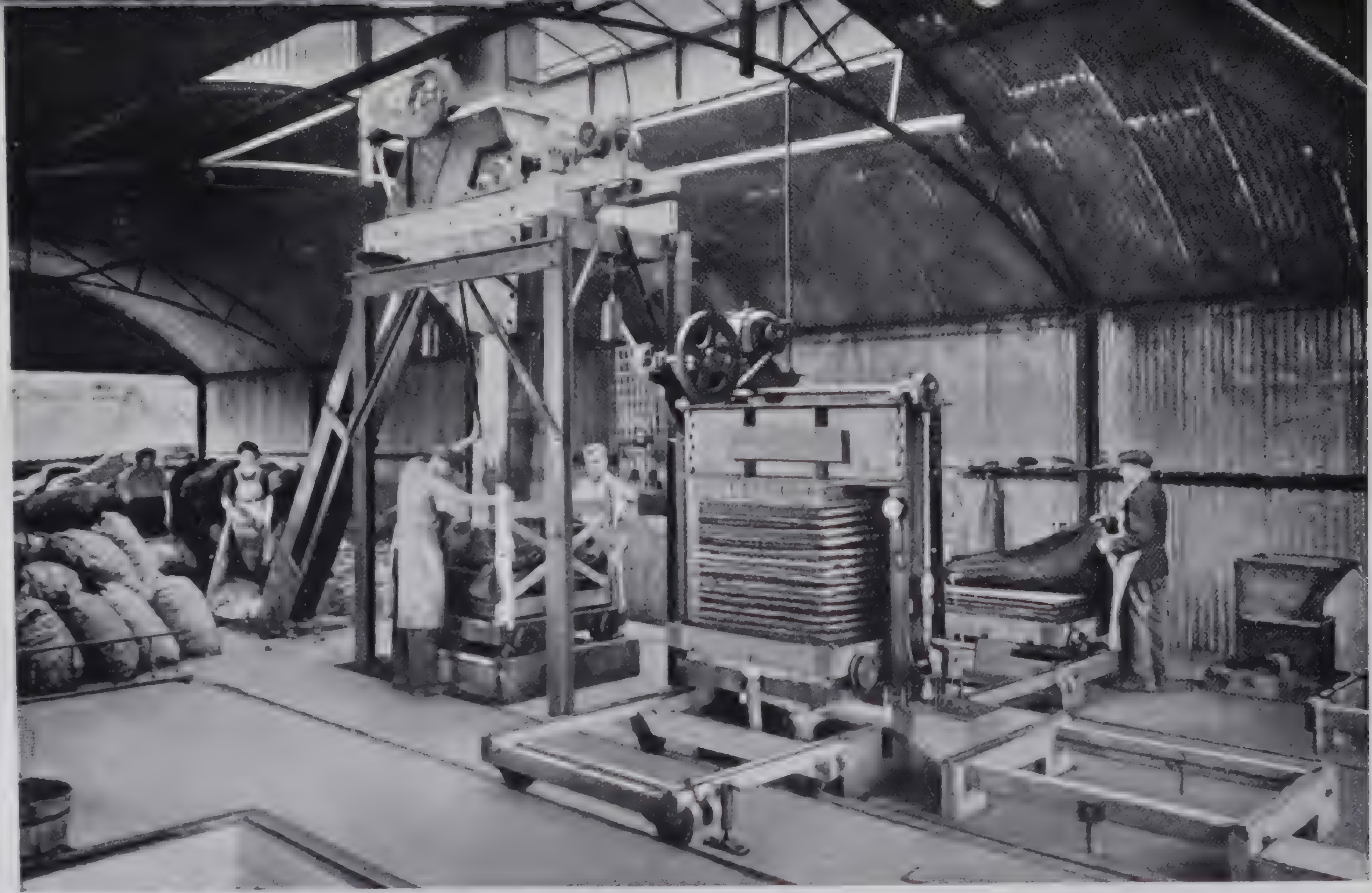

Fig. XIV. 100-ton Hydraulic Pressing Plant (Beare Type)

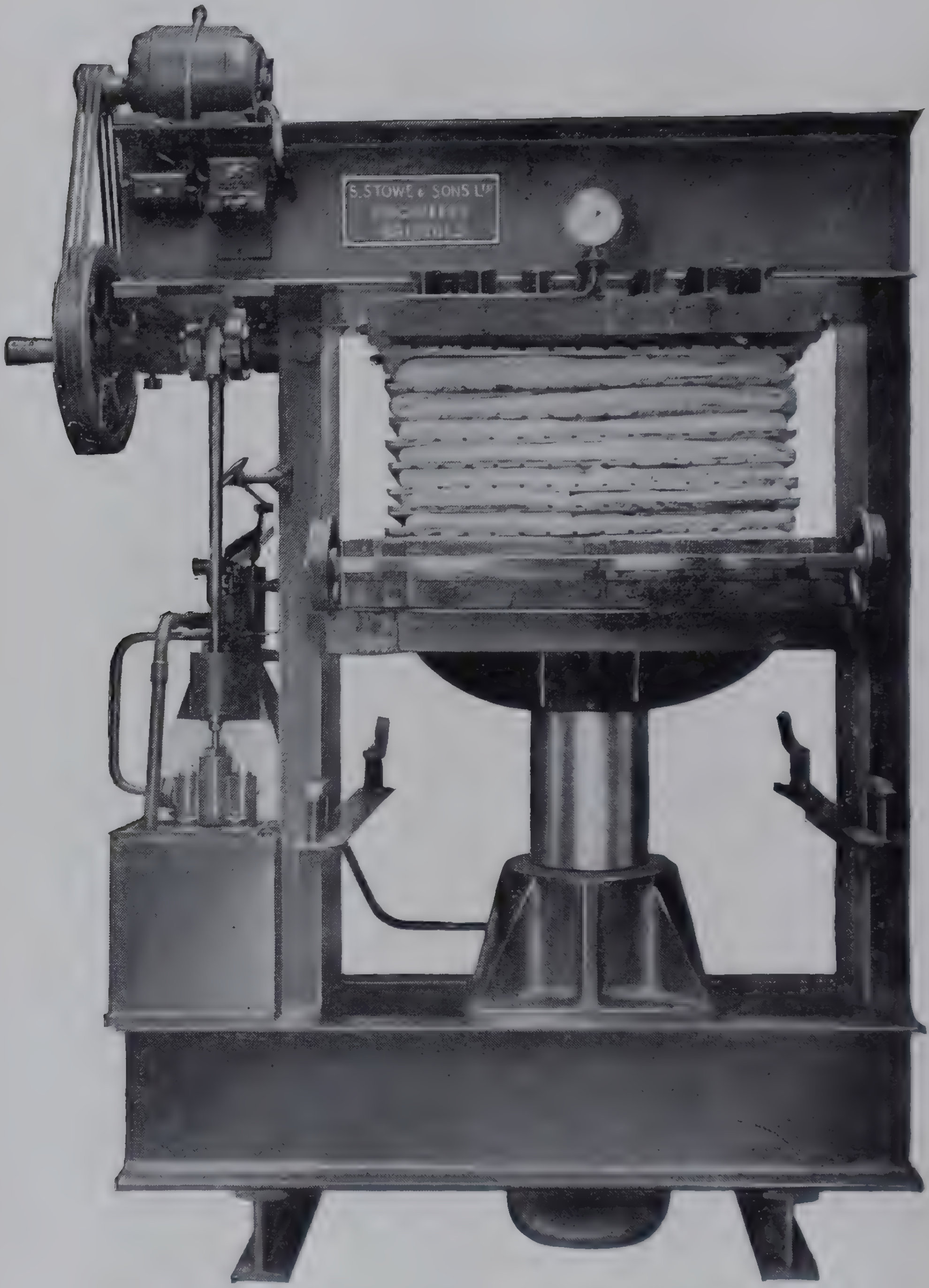
S. STOWE & SONS LTD

Fig. XV. Stowe 125-ton Hydraulic Press

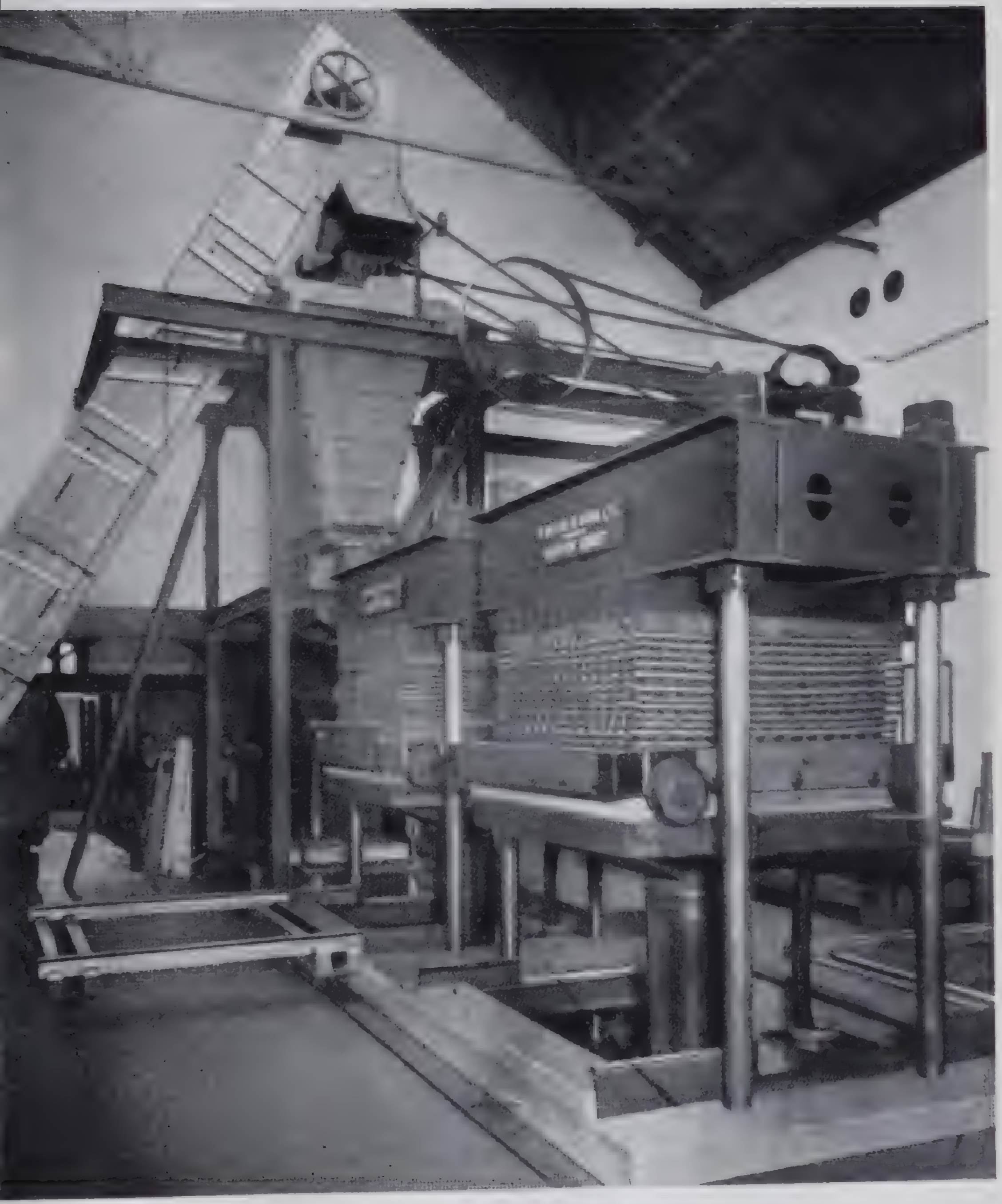

Fig. XVI. 220-ton Hydraulic Pressing Plant (Beare Type)

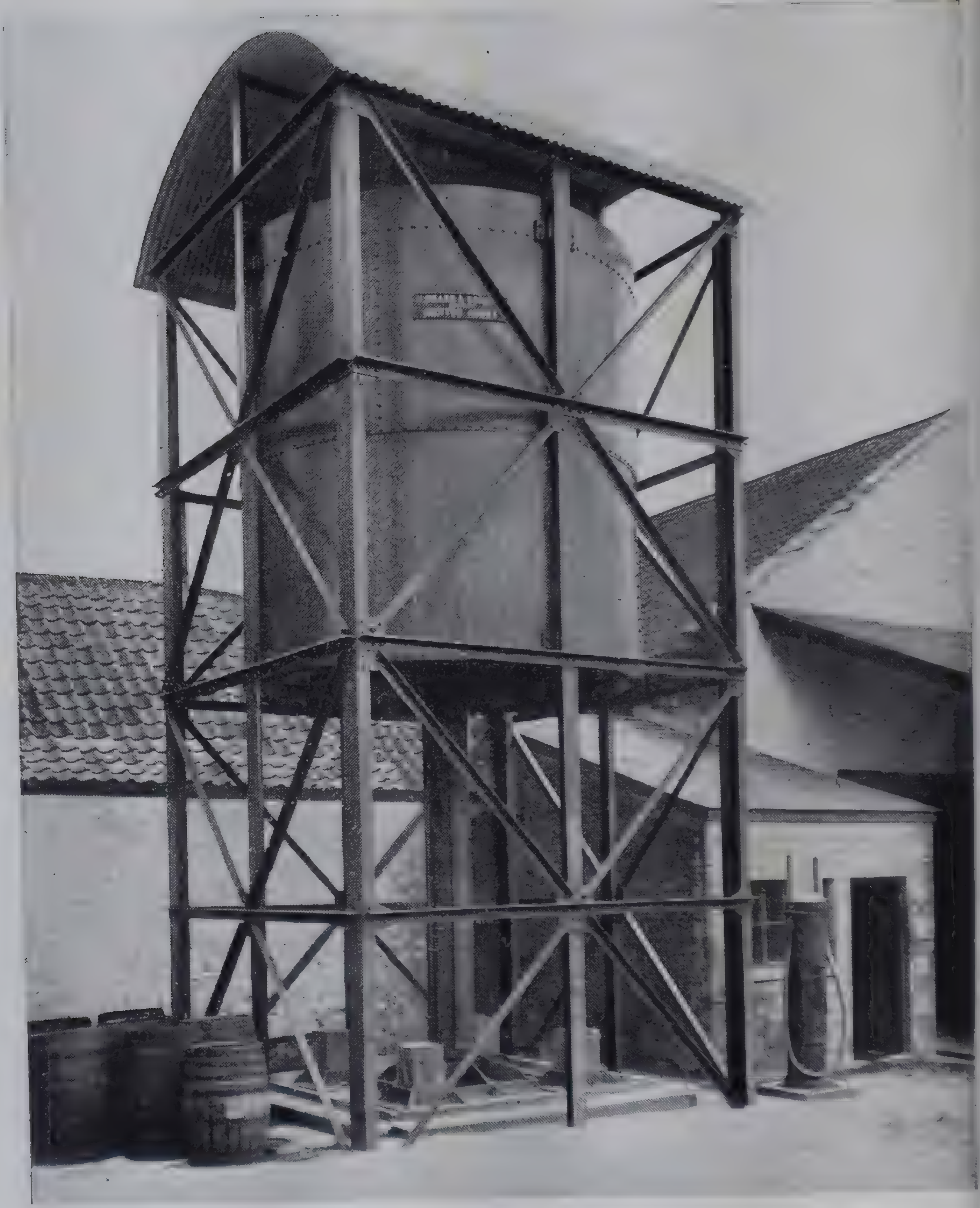

Fig. XVII.—Hydraulic Accumulator for Cider Press (Beare Type)

Conclusions

The previous sections have dealt with the best means of ob- ining a pure juice by pressing the pulp and it is now possible appreciate why many farm cider-makers produce ciders with ery poor keeping qualities.

The cleanliness and hygiene of the farm cider factory is in- lequate; the various machines are rarely cleaned thoroughly nd they become the source of infection and contaminate all e fruit and pomace with which they come in contact. The aceration of the fresh pulp in its own juice is often carried n for an excessive time and there is a consequent loss of tannin, emoving a constituent from the cider which possesses unique apabilities in suppressing maladies. Despite these defects, how- ver, the chief fault in the farm cider-making practice is the ay in which the resoaking and re-pressing operations are ef- ected. The maceration with water often takes place in vats with ery large surfaces; each period stretches from 12-24 hours, so hat with large presses where the building of the cheese is a engthy process, the complete exhaustion of the pomace will ake 4-5 days. Acetification is thus induced. Warcollier has ound 0·25% acetic acid in mixed juices ready for the main ermentation process; this percentage of acetic acid is usually ound only in 'hard' ciders and is much too high for general cceptance. To prevent acetification, attention should be paid o perfecting the sterilisation of all the plant used for obtaining he juice; maceration of the pulp in its own juice or in added vater should be carried out in sufficiently deep vats; the actual perational movements of building cheeses, etc., should be car- ied out as quickly as possible. Unless several presses are avail- ble, the cider-maker should concern himself merely with the xhaustion of one batch of pomace at a time. Speed must be the ssential feature of this type of process.

Preparation of the Juice by the Diffusion Method

The provision of juices by the pressing method with resoaking reatment leads to the production of diluted ciders and only chieves a partial exhaustion of the pomace. A search for a nore efficient method led to the introduction of the diffusion rocess. This had been used successfully in the sugar industry but has not proved to be equally efficient for removing th juice from apple cubes.

In the sugar refinery, the technician is working with dea cells which have been killed by temperatures of 75-80°C., an in these cases the straightforward laws of diffusion are applicable. The amounts of any substance diffused through a membrane in a given time are proportional to the concentration o the solution; the quantity will vary for each substance; risin temperatures will increase the amounts; and finally, if two solutions of the same substance of unequal concentrations are concerned, the diffusion rate will increase proportionally to th difference in concentration between the two solutions. Wit mixed solutions, there are other considerations involved.

The substances which diffuse (dialyse) most easily are crystalline in nature; i.e. sugars, acids, tannins. Poor diffusion is feature of colloids, examples of which, in fruit juices, are nitrogenous compounds, gums, pectic substances, etc. The final equilibrium is more rapidly attained with crystalloids than wit colloids.

In cider-making practice, one cannot diffuse apple cube (cossettes) at 75-80°C.; on the contrary, the temperature canno rise above 30°C. without compromising the success of the diffusion process. The apple cells are not dead; many are not eve broken; very complex physical chemical phenomena are concerned with the process of osmosis which comprises the movements of water either into or out of the cells until an 'osmoti equilibrium' has been attained. The presence of pectins wil complicate the process and slow down the diffusion.

This process calls for machines to cut the apples into cube and a battery of diffusers. Dicing machines are available for thi purpose. The efficiency of the extraction of juice is partly dependent on the use of clean fruit and the provision of cubes wit sharp edges. Apple mills are useless and rotten fruits complete prejudice success. The battery of diffusers is composed of 10-1 containers; each vessel is inter-connected and can be supplie with water and a special tap for the removal of juice. Diffuse are generally cylindrical in form; they can be constructed fro casks that have been sawn in half. They may be open or closed in the latter case, wooden tops seated on a rubber joint can b used. Each vessel should be provided with a false botto rced with holes and covered with a layer of thick cloth or vas on which the apple cubes are placed. Above the cubes aid a perforated rack, held down by bolts, which prevents of pulp when this becomes swollen with juice. For ease of nipulation, each diffuser is hung on two bearings so that it be tilted over and emptied into a gulley when its pulp is hausted.

At the commencement of a diffusion, the primary diffuser ceives the apple cossettes, and the final vessel is treated with ter. Each vessel can become the primary or final diffuser in rn.

The juice should flow downwards through each diffuser, ex- pt when the primary vessel is being filled with juice. In this se the juice is led into the bottom of the diffuser so that the is expelled from the cubed apples as the juice rises through e fruit. When the diffuser is full, the juice is passed to the top the next vessel, and similarly for all the other vessels.

The progress of diffusion is as follows: the water is passed to the top of No. 1; juice flows from the bottom of No. 1 and led to the top of No. 2, and similarly through the whole series. hen No. 1 is exhausted, it is emptied and refilled with fresh ssettes. Fresh water is then caused to flow first into No. 2 d the juice issuing from No. 10 is led to No. 1. The vessels n be arranged in one row, two parallel rows or in a circle; ey can be fixed or mobile.

Many different systems have been introduced for the cider dustry. Among these may be cited:

Briet, cold process and open diffusers.
Fossier, cold process and open diffusers.
Laforêt, cold process and closed diffusers.
Levasseur, cold process and closed diffusers.
Nercan and Laforêt, hot process, with closed diffusers.

There is an almost endless variety in the design and operation diffusion systems in cider installations; each maker has intro- uced some novel feature and it is impossible to describe the tire range of processes that have gradually been evolved. arcollier has found no significant difference between processes hich utilise closed or open diffusers; the hot process is rarely ed. The adoption of a temperature of extraction of 18-20°C. ten leads to fermentation and the evolution of carbon dioxide gas will interfere with the operation of the battery unless special arrangements can be made to remove the gas.

Yields of juice vary with the amount of water which is passed into each diffuser. Should it be desirable to produce juices with gravities approaching those obtained with a hydraulic press, the battery must be operated with only limited quantities of water, say 180-190 gallons of water per ton of apples. The speed of diffusion must be slow; indeed, so slow as to become uneconomical and to render the pulp susceptible to the danger of fermentation. In other words, the diffusion system cannot be used in a practical way to produce pure apple juices. The highest purity obtainable with economical running is 80%; i.e. the gravity will be 80% of that of a juice produced by hydraulic pressure from the same apples. As an example of the operation of a battery of diffusers, Warcollier cites the following instance.

The battery consisted of 11 vessels, each of 154 gallons capacity, and each holding 5 cwt. of fruit. 55 gallons of juice were collected from each diffuser, equivalent to 11 gallons of juice per cwt. of fruit. Each vessel needed 50 minutes for exhaustion, so that in 12 hours, 790 gallons of cider of gravity 1·040 were produced (the pure juice gravity being 1·050).

The operation of a battery should be closely supervised. The same weight of apple material should be placed in each vessel, and the routine should be continuous through night and day. Many factories cannot arrange for such facilities and in these cases the process is allowed to proceed during the night hours at a very slow speed so that the dangers of fermentation are, to some extent, minimised.

Séguin and Pailheret, using an apparatus of the Briet type, have come to the following conclusions concerning the diffusion system:

(*a*) The juices contain all the constituents of the apple that are found in juices obtained by hydraulic pressure, and these constituents are present in at least equal proportions.

(*b*) The amount of yeast in the juice is sufficient to ensure complete fermentation.

(*c*) The taste and composition of diffused juices is equal to that of the juices from the presses.

(*d*) The diffusion system can produce pure juices.

(*e*) Diffusion produces a high yield of juice and cider. 1 ton of apples gives the undermentioned yields in gallons:

	Pressing	*Diffusion*
Juice at 1·056 gravity - - -	161	189
Pure Juice cider - - - -	139	186

(*f*) The various constituents in the juices provided by the vo methods are shown here:

Pressing %	*Diffusion* %			
100·00	99·00	of the total acidity of the apple		
84·00	93·30	,,	glucose	,,
86·95	89·13	,,	tannin	,,
67·37	97·44	,,	gums, etc.	,,
50·33	66·67	,,	ash	,,

Comparison of Pressing and Diffusion Methods

Advantages of diffusion.—These may be summarised as follows:

(*a*) More complete exhaustion of pomace.

(*b*) Less labour for operation (two men per 10 vessels).

(*c*) Control is simple.

(*d*) The plant is cheap and easily made by the cider-maker imself.

(*e*) The juices are clear, fermentation normally proceeds vithout forming an excessive brown head. The ciders are clear nd can be sold in a naturally sweet condition without artificial larification; they are especially suitable for bottling.

(*f*) These ciders seem to possess stronger bouquets than any other type. They ferment more quickly and in a completely dry condition they appear to retain more body than ciders from pressed juices.

(*g*) The diffusion process is especially suitable when slightly diluted ciders are desired.

Disadvantages of diffusion.—(*a*) Very ripe fruit cannot be used; large volumes of water and a 24-hour working day is essential. A factory using 20 tons of apples a day with two hydraulic presses, should install, as a direct equivalent, six batteries of eleven diffusers each containing 5 cwt. of apples.

(*b*) The diffusion process ultimately provides a pulp which contains up to 90% of water. This pulp cannot be dried until it has been pressed to reduce the surplus water content to a more normal figure.

(*c*) Diffusion cannot give absolutely pure juice ciders (i contrast to Séguin and Pailheret's views).

(*d*) Ciders made by diffusion are generally pale.

In this final summing up, Warcollier, whilst expressing hi firm belief in the future of the process, is forced to admit tha the results up to 1928 had been discouraging. The future o the process lies, in his opinion, in the examination afresh o the method of operation and the provision of more adequat plant.

Various Other Methods of Juice Extraction

(*a*) *Crude Diffusion.*—A rough and ready diffusion method i available for small makers who have no press and who onl desire to make very dilute ciders. The apple pulp is placed i an open barrel, fitted with a false perforated bottom. The pul is prevented from overflow by a loose top. Water is added an allowed to macerate in the pulp and the juice is collected. Th process is repeated two or three times and the various fraction of juice are mixed together.

(*b*) *Process Using Four Vats.*—Four vessels are placed at variou levels each lower than the preceding one. In order that the process may be described, let it be supposed that No. 1 is the highes vessel, and that Nos. 2, 3, 4 are each lower than the precedin one, so that the juice from each vessel can be led into the nex lower vat. The four vats are filled with pulp; water equal i weight to one-third the weight of pulp is run into No. 1; this i left to macerate for six hours, after which period the juice is ru into No. 2; No. 1 is again washed with water. After six hours the juice from No. 2 is run into No. 3, and the washings fron No. 1 into No. 2. No. 1 is again washed with water. When No. releases its juice, it is considered that No. 1 is exhausted. I is emptied and refilled with fresh pulp, placed beneath No. and in this way No. 2 vessel becomes No. 1, and the proces continues.

This process is due to Nanot and is superior to the previou method, but is inferior to the properly conducted diffusion system with 8-10 vessels. The loss in sugar amounts to 25%.

(*c*) *Method of Louïse and Pihier.*—This method has never bee employed on a commercial scale. The pulp is ground to a fin state of division and placed in a battery of seven diffusers i ich develops a straightforward maceration and leaching of e pulp. Pure juices can be made in this way. The various ssels are not joined in series, but are separately emptied by eans of a plug in the false bottom. It is said that fine quality ders can be made by this process and it would appear to be orthy of fuller examination.

(*d*) *Method of P.-B. Noël.*—This procedure is, in reality, a eans of operating a methodical resoaking process by exhaust- g the pressed pomace material with hot water. Seven to twelve essels are used, each provided with a false bottom and a loose over to prevent loss of pulp. The vessels are filled with two- irds their capacity of pulp. No. 1 vat receives water at 40°C.; fter one hour, the liquor from No. 1 is led to No. 2; No. 1 is en filled with water at 50°C. Ultimately, No. 1 is washed with ater at 80°-90°C. When the battery is in full operation, the st diffuser receives water at 80°-90°C.

Hot water extraction gives liquors that are more highly fla- oured and more aromatic than those produced by the ordinary aceration process. This treatment with water at 90°C. kills e fruit cells and extracts from the skins the odorous constitu- nts which are largely found in these specialised tissues.

Experimental Maceration (*Pique Method*)

In 1920, Pique introduced a method of maceration which onsisted of a methodical exhaustion of the apple cossettes with ot water; the solution was led through six further open diffu- on vessels, similarly filled with cossettes, so that the maximum xtraction of soluble constituents was achieved. The experi- ents were fundamentally similar to those previously discussed the section on diffusion methods of juice production. A ecial feature of the Pique method, however, was the addition f 7 oz. tartaric acid per ton of apple cossettes to facilitate the lution of the apple aroma from the skin.

The experiments provided the following results: After the ice had passed through each vessel twice, i.e. through 14 ves- ls in all, 1 ton of apples gave 218 gallons of juice with a gravity f 1·030. If the cycle was reduced to a single passage through vessels, the gravity was raised to 1·042, compared with a ravity of 1·062 for a juice from a hydraulic press.

Consideration was then given to the possibility of the process giving better results with once-pressed pomace than with cossettes. Pique obtained by this modification 220 gallons of juice with a gravity of 1·031 from 1 ton of once-pressed pomace. The extracted pomace after this form of treatment no longer contained any sugars. This yield of juice is interesting, but it must be observed that the once-pressed pomace used in the experiment should have been very rich in sugar, for the apples had given by a single pressing a yield of only 35·5% of pure juice.

Pique expressed his conclusions as follows: 'Maceration diminishes manual labour; resoaking of the pomace ensures a clear, aromatic juice, of a gravity comparable with straight juice; with regard to speed of operations, four men working a battery in which each vessel holds 10 cwt. of pulp can deal with the pomace from 30 tons of apples in 10 hours.'

Preparation of Juice by Centrifugation

This process is only occasionally employed. The apple pulp from the mill is placed in large cloth bags inside a centrifuge rotating at 1500 r.p.m. The juice is thrown outwards by the centrifugal force, passes through the cloth and is collected outside the rotating bowl. Some cider-makers claim a very satisfactory yield; i.e. 12½-14¼ gallons of juice from 2 cwt. apples in 15 minutes (i.e. 125-142 gallons per ton).

Very few exact experiments have been reported on this subject, but Warcollier has given figures for some trials of his own carried out at the factory of M. Camille Masselin at Bernay (Eure). A centrifuge rotating at 1800-2000 r.p.m. and holding three large bags of pomace provided by a Simon mill, gave 112 gallons of juice per ton of apples. The centrifuge was driven by a 2 h.p. motor and accommodated 110 lb. pulp at each setting, a complete operation occupying 9 minutes. The juice became extremely aerated during the centrifugation. The centrifuge should be used in association with a stream of carbon dioxide, and the metal from which it is fabricated should not affect the cider.

Adjustment of Freshly Pressed Juices

It has been emphasised in an earlier chapter that in the manufacture of cider of a given type from a known mixture of pples, one can obtain an idea of the average composition of e juice and its content of sugar, acid, tannin and pectic sub-ances. These average figures can only be determined after a rvey of the analytical figures over a reasonably long series f years.

Having once established these data, it is possible to effect ertain modifications in fresh juices in abnormal years when the uices show considerable divergencies from normal conditions.

Lack of tannin can be remedied by blending with more bitter ruit rather than by the addition of tannin itself.

The pectin content can be increased by utilising an anaerobic aceration of the pulp, or by postponing the milling of the ruit until the apples are fully ripe.

Should the sugar or acid contents be lower than the average or the same fruit, the deficiency can be made good by adding ucrose, or tartaric or citric acids.

Finally, the correction of the chemical composition of juices an be ensured by adding another type of juice of such a com-osition that it provides the constituents which are lacking. This type of chemical control is only possible in factories where analyses of juices are carried out immediately they are collected from the press.

Sweetening

The State Regulations of 24th September 1933, enforcing the law of 1st August 1905, for the suppression of frauds, authorises the sweetening of apple juice by the addition of unlimited quantities of sucrose provided that the amount of sugar used does not alter the essential nature of the product. The use of sugar should not be on such a scale as to convert a diluted cider (*boisson de pommes*) into a normal cider (*cidre*), or a normal cider into a pure juice cider (*cidre pur jus*).

The sweetening agent should be crystallised beet or cane sugar. The crystals should first be made into a concentrated syrup which is then mixed into the juice. It is useful to recall that 23 lb. of sugar dissolved in 100 gallons of juice will provide 1% by weight of alcohol after complete fermentation.

The use of impure brown sugars, glucoses, molasses or honeys in ciders that are to be marketed for general consumption is forbidden in France.

Saccharin is forbidden as a sweetening agent for juices and ciders (its use was, however, temporarily authorised during the 1914-18 war and until October 1922).

Acidification of Juices

The same law in France allows the addition of two substances only for this purpose, tartaric and citric acids. They may be added singly or in combination, but the total quantity added must not exceed ·05%.

Where the desired acidity of the juice cannot be attained even by the addition of the maximum allowable amount of acids, the blend of the fruit must be altered and a proportion of very acid fruit incorporated in the mixture.

Reduction of Acidity in Juices

Juices which contain more than ·8-1·0% malic acid should be treated in such a way that the acidity is reduced. This can be done, before fermentation, by adding pure precipitated chalk in the proportion of 1-2 lb. per 100 gallons. The taste and general quality of the cider is thereby improved. The excessive acidity of some juices can obviously be reduced by blending with sub-acid types of fruit.

TRANSLATOR'S ADDENDA

Pressing

The essential features of juice expression in 1949 remain much the same as those that existed in 1848. Only in matters of design and increased application of pressure have there been any substantial improvements. The much-publicised continuous presses referred to by Warcollier have made very little headway, and are, indeed, now used only for removing excess juice from pressed apple pomace prior to the drying process in a continuous drier or for the preparation of juice for quick fermentation for distillation.

The main improvements in design are concerned with details of size and the pressure exerted per unit area on the cheese. Swiss and German technique has tended to develop much higher pressures in the interests of increased yields of juice. Modern French technicians, however, assert that pressures of

-430 lb./sq. in. are uneconomical and that there is no need exceed 140-170 lb./sq. in.

Typical modern English presses are shown in Figs. XIII, V, XV, XVI. The first photograph shows a small 30-ton ess suitable for farmers. It is a self-contained unit with mill, ess and pump all assembled in one frame (Stowe type). The her presses are associated with a series of transfer trucks so at cheeses can be built simultaneously with the pressing operion. A 100-ton press is capable of dealing with 20-25 cwt. of uit per hour, using a cheese 3 ft. square and 3 ft. 8 in. high. g. XIV shows such a press (Beare type) and associated plant cludes the fruit elevator, mill, pomace vat and measurer to gularise the amount of pomace received into each cloth. Fig. V illustrates a further design with attached hydraulic pump towe type, 125-ton size). A larger size of English press (Beare) illustrated in Fig. XVI. The specification is given as 220 tons .e. the *total* pressure exerted by the ram on the entire cheese). uch presses are usually operated by accumulators (Fig. XVII) account of their size and the considerable speeding-up of perations that can be thereby achieved. A feature of these rger installations is the truck lift associated with the truck on hich the cheese is built. The lift is raised to its highest extent efore commencing to build the cheese and is lowered to a itable degree as each cloth receives its quota of pulp and is parated from the next by the succeeding rack. By this means e workmen responsible for the building of the cheese are connuously confronted by a cheese whose top surface remains at e same level, and exaggerated movements either in a downard or upward direction are entirely avoided.

During the past twenty years, the German and Swiss makers f cider-making machinery have developed turntable presses in hich the whole bed of the press rotates around a central axis, us avoiding the use of transfer trucks (cf. Kleeman type). uch presses, however, are relatively expensive on space. A very ecent extension of this type of machine is that built by Bucher-uyer in Switzerland, and which probably represents one of e most up-to-date and efficient hydraulic presses available Fig. XVIII). The press is composed of three 'beds'; the cheese built in one set position, the cloths being filled by an autoatically driven measurer for the pulp. A feature of this fitment is its control in such a way that the pulp is released at definite regular intervals of time so that it is essential that the workmen shall carry out the necessary operations (folding the cloth, placing a fresh rack on the cheese and covering this with an open cloth) before the next quantity of pulp is discharged onto the cheese. The speed at which these discharges take place can be adjusted to suit individual conditions. The press includes permanent fitments to carry the cloths and racks and these are placed in a manner most convenient for the workmen. The rotation of the whole body of the press is achieved with the utmost simplicity; each cheese is pressed twice and a third movement brings the twice-pressed cheese to the unloading position, where the cloths and racks are removed and placed on their respective stands. Such a press can deal with 35-40 tons of fruit per day. No disintegration of the pomace can be undertaken between the two pressings, and this may vitiate to some extent the efficiency of juice removal. On the other hand, the secret of high juice yield is apparently closely connected with the building of quite thin layers of pulp, the thickness never exceeding 2½ in. in each cloth.

One further adjunct to pressing equipment is worthy of mention. The disintegration of once- or twice-pressed pomace is now generally effected by a machine of normal design but associated with a fan which pneumatically blows the pomace through steel tubes either to the required position for rebuilding the cheese for second pressing or direct to the drier (Fig. XIX). These fans are now made with sufficient power to drive the pomace over considerable distances, and the system is capable, if correctly designed, of effecting a remarkable saving in manual operations as well as ensuring a quick and hygienic manipulation of the once- or twice-pressed pomace. A similar procedure may be normally employed to convey the dried pomace from the outlet of the pomace drier to the bagging room. The hot pomace can be sufficiently cooled in transit to be filled continuously into bags without danger, if the pomace is efficiently dried, of overheating.

Diffusion Process

This procedure has not increased its popularity in the past twenty years, and is now used only for the production of dilute forms of cider (*boissons de pommes*).

Second Pressing of Once-Pressed Pomace

Charley and Kieser (1) investigated the various methods of bstracting some of the residual juice remaining in once-pressed omace. Re-pressing of the disintegrated, once-pressed pomace ave additional pure juice to the extent of 4-17 gallons per ton f apples, the yield varying with the variety and maturity of he fruit. The addition of limited quantities of water to the isintegrated pomace before re-pressing enabled appreciable mounts of sugar, pectin and tannin to be removed from the omace, although a very marked diminution of tannin content as observed when the pomace was allowed to macerate with he added water for an extended number of hours. The fairly lose correlation between the permanganate-reducing figure btained in the tannin estimation on ciders and the astringency f the product as discernible by the palate was not reproduced n the case of second-pressed extracts when using water additions. Whilst the chemical determination of 'tannin' gave considerably lower figures, the astringency was not reduced to the ame extent.

Pickford (2, 3) has studied the improvement in flavour to be btained by re-pressing pomace from bittersweet apples with he juice from culinary fruit. It was eventually found unnecessary to allow the pomace-juice mixture to stand for 12-24 hours efore pressing, as had previously been understood to be the ase. The blending of the two materials in the proportion of ne part of bittersweet to three parts of culinary fruit gave very atisfactory results.

REFERENCES

(1) Charley, V. L. S., and Kieser, M. E., *Ann. Rept. Long Ashton Res. Sta.*, 1940, p. 89.
(2) Pickford, P. T. P., *ibid.*, 1933, p. 141.
(3) Pickford, P. T. P., *ibid.*, 1935, p. 145.

CHAPTER VIII

PLANT MAINTENANCE AND FACTORY HYGIENE

THE farm cider-maker is little inclined to alter his methods even when some economical procedure has been suggested to him. He is conservative, preferring the old, known way of working, to what he regards as new-fangled methods which cannot offer any advantages over his well-tried routines. Now, all those industries concerned with fermentation processes which have advanced and prospered have not been afraid to break with old customs and prejudices and to introduce into their factories scientific methods which have been shown to be improvements over their previous treatments.

The cider-maker, whether he be concerned with a large factory or merely making cider at the farm, should concern himself a great deal more than he does with cleanliness and hygiene. It should become abundantly clear to him that 'apparent' cleanliness of plant and floors can be deceptive and that nothing short of complete cleanliness should satisfy him. Every corner, nook and cranny of his premises should be free from impurities and organisms before the buildings are really fit for the production of cider.

This complete sterility of the premises provides a heavy task on the farm. The presses are cumbersome, the workmen tread pomace all over the floor and press it into cracks between the stones. In the off-season, the buildings are often used by fowls which, perching wherever they please, foul the premises and add their quota to the organisms' putrefying process.

The press room is usually badly ventilated and the floors are often neither covered with flagstones nor are they sloped; proper washing down is impossible. The walls are not plastered and often show cracking that no paint brush can effectively explore.

The same criticisms can be made of the cellars. The spilling of cider or juice moistens the soil with a product which develops micro-organisms of various species; when the surface dries off,

en the light, fine dust blows everywhere, contaminating every-
ng that it contacts.

The best procedures for ensuring maximum cleanliness will w be considered.

Buildings

The cider-making buildings should be used for that purpose nd that purpose only. Everything that could cause infection or rovide a contamination should be removed. The most modern rater machine should be installed for milling the apples, and ne old cumbersome presses should be replaced by one or two naller machines which are easier to handle and are more eco-
omical in use. Provision should be made to collect the juice om the presses in closed containers sunk in the ground; the oor should be covered with stonework, there should be plenty f light and air and the walls and ceiling should be thoroughly eaned.

One month before the making season commences, all vessels nd plant should be inspected so that minor repairs and a nal complete cleansing of the whole plant can be undertaken.

The stone walls of the premises may be painted or sprayed ith a coating of lime. Two recipes have proved their value for is purpose:

Quicklime - - -	10 parts	10 parts
Copper sulphate -	2 ,,	1 ,,
Calcium chloride -	1½ ,,	1 ,,

The mixture should be carefully prepared to break down the umps, and in this state the fluid can be most efficiently applied rough a spray gun operated either by hand or by a pump. he quantity of water to use is about twenty times the weight f lime. Alternatively, it is possible to use the residue left when alcium carbide is used for the production of acetylene.

The lower portions of walls should be painted or sprayed ith a dark coloured wash. Caves and cellars should receive milar treatment; hard floors should be provided wherever it possible. Suitable provision for washing down the premises nd the removal of surplus water must be considered.

Such action as is here suggested will have the effect of re-
ucing contaminations from moulds such as *Aspergillus niger*.

Wooden Apparatus

Tubs, buckets, jugs, baskets, shovels, hoppers, racks should all be carefully cleaned. First, they should be thoroughly scraped and brushed, then washed with boiling water in which has been dissolved 1 lb. soda in each gallon. A final washing in clean water completes the process. If then a mouldy taste still persists, treatment with calcium chloride (1% solution), with or without addition of sulphuric acid, may be of use. The odour of chlorine should be removed by washing with large quantities of water.

During the season, washing with soda should be repeated every week, and plant should be swilled down with clean water every other day. Moulds such as *Mucor* and *Penicillium* and acetifying bacteria are thereby kept under control.

Cloths

These should be soaked in water containing 10% calcium bisulphite, and washed thoroughly immediately the slightest acetic smell is apparent. Water containing a small proportion of eau-de-Javelle (a special mixture of potassium chlorite and potassium hypochlorite in solution) may also be used.

Metallic Plant

Mills, knives and presses should be kept in a clean condition. During the off-season, they should be well greased. In the working season they should be washed down every night to avoid excessive solution of iron in the juice with a consequent darkening of the cider later. All tubes and pumps in bronze, copper or tin should be washed after use with soda solution or steamed out. Rubber tubes and pipes can be cleaned with 5% calcium bisulphite solution, which is allowed to stay in contact with the rubber for 30 minutes.

Concrete Vats

Concrete vats must be maintained in a proper state of cleanliness. They can be treated with a solution of tartaric acid (3 lb. per gallon) either by a spray or by brushing by hand. 2 lb. tartaric acid is generally sufficient to cover 200 sq. ft.; this quantity, however, is only an approximate estimate, as the pre-e requirements for tartaric acid will depend on the amount basic material in the concrete.

The tartaric acid should be applied twice and the vats should en be filled two or three times with water before being used.

Concrete tanks and vats which are not lined with other aterials (i.e. such as bitumen or glass tiles) should be coated th a silicate or 'Fluate' lining.

The application of a silicate lining is effected by the use of otassium or sodium silicate which is sprayed on to the surface. he silicate fills up the pores of the cement and forms basic icates which are only slightly attacked by the fruit acids. he silicate solution should be 30°-40° Brix in strength. The t is first washed out, then washed with 10% sulphuric acid lution (10-14 gm. sulphuric acid are needed per 10 sq. ft.); xcess acid is then removed by rinsing. The vat is left full of ater for ten days prior to application of the silicate. Three oats are applied, allowing each to dry before applying the ext. The first coat is applied at 25% strength, the second at 0%, and the last at 50%; the excess of silicate is removed nally by thorough rinsing. The complete process should be epeated when necessary, as the silicate lining scales off easily.

A further method is known as fluation, and has been de-eloped by Kessler. The details are given below:

(*a*) The dry cement is brushed over with a 20-25% solution f magnesium fluate, allowing time for the maximum absorp-ion. This process is repeated two or three times at 12-hourly ntervals, so that the cement eventually absorbs 12 oz. of liquid er square yard.

(*b*) The surface is then treated with 15% aluminium fluate, o that 6 oz. of liquid are absorbed per square yard. After drying, the surface is rinsed until no taste of the fluate can be detected.

(*c*) With a dry brush, the surface is impregnated with a paraffin wax preparation.

Special linings are available which give excellent protection o the concrete, but the secret of success in such linings is to apply them to absolutely dry surfaces.

Many factories use a film of paraffin for covering their cement vats. Here again, the surface to be covered with paraffin must be absolutely dry. The vat should be washed out with water, slightly acidified with sulphuric acid, and dried. Paraffin is employed at a maximum dose of 15 oz. per square yard; it is heated to 180°C. and applied with a hard brush; the normal painting stroke should not be used, but the paraffin should be dabbed on to the concrete, to ensure filling up the pores. When the surface has been completely covered, a smooth glossy effect is achieved by heating with a blow-lamp and polishing with a rag.

Some concrete vats are protected by glass tiles. The method is not so popular as it was formerly because of the difficulties of jointing the tiles together so effectively as to prevent any leakage of the cider behind the tile. Any defect in the jointing material leads to fermentation behind the tiles with evolution of gas and consequent rupture of the lining.

The underground vats should be maintained in a state of complete cleanliness and freed from acetic bacteria. To remove completely the taste of acetification from a vat, it can be washed with water containing 3 oz. soda per gallon, following this by several rinsings with water. Sulphur dioxide is an excellent antiseptic which prevents the development of acetification. The vats may be treated by the burning of sulphur or by introducing a dose of sulphur dioxide equivalent to 9 gm. ($\frac{1}{3}$ oz.)/100 gallon capacity. Lastly, the surfaces of the vat may be washed over with water containing sulphur dioxide, rinsing away any surplus that remains.

Casks

The exterior of casks and all other wooden vessels must be kept clean. Hoops should be serviced or replaced, and painted to preserve them from rust.

New Casks.—There is always some woody taste in new casks due to tannins and resins from the material of which the cask is made. Such casks should be steamed if an apparatus is available for so doing. Alternatively, the barrels are washed with water acidified with sulphuric acid (0·2%). The acid should always be added to the water as it is extremely dangerous to add water to the strong acid. Again, a hot solution of potassium permanganate (0·1%) and marine salt (0·25%) can be used for the same purpose. After either of these processes, the casks are dried and are ready for use. They may, at this stage, be lined with some proprietary material, with paraffin or some

m of wax, procedures which are very popular in brewery
hniques.

Used Casks.—These should be continually subjected to general
eaning and to treatment with sulphur dioxide. Certain Swiss
d English factories prefer paraffin wax lining for all their
sks, using a special machine which introduces the molten
araffin into the casks as a spray. Hot water washing should be
oided in the case of casks which have received this treatment.

Casks that are in need of very special attention will need a
ariety of treatments according to the nature of the defect.

(*a*) *Dry Casks.*—These should either be steamed to tighten
the staves and hoops, or be submerged in a tank of water
ntil the desired effect has been achieved. Casks should always
e washed immediately they have been emptied and should
ever be allowed to stand empty or with their lees still remain-
g in them for any length of time. Such treatment often renders
cask quite useless for further service.

(*b*) *Casks used for Acetic Ciders.*—These should be washed with
oiling soda or potash solution (2% = 3 oz./gallon).

The solution should be well swilled around the cask and
llowed a long time for its action. Rinsing out with cold water
ompletes the process.

(*c*) *Mouldy Casks.*—If the cask is seriously affected, the most
nergetic action will be needed to sweeten the wood. First, a
horough scraping is essential. The staves should then be planed
lown or burnt with wood shavings until a clean surface is pro-
ured. This should be left to a skilled cooper, as it is extremely
lelicate work and needs considerable experience to ensure suc-
ess. When the affected portions of the staves have been re-
noved, the cask is brushed out and washed with a warm 1%
olution of sulphuric acid, followed by copious supplies of clean
vater.

(*d*) '*Stinking Casks*'.—When soda treatment in hot water does
ot remove the offensive smell, equal volumes of calcium chlor-
de and sulphuric acid may be used. The former is used at the
trength of 3 oz. per gallon of water, and the acid is made up
y adding 230 cc. per gallon of water. The cask is closed and
olled around. The evolved chlorine gas is an active agent in
destroying foul smells, and after a suitable time the chlorine is
removed by rinsing out with clean water.

(*e*) *Cleaning of Casks used for Red Wine.*—The cask is first washed with a 5% solution of hydrochloric acid to remove the tartar; this is followed by treatment with 5-10% soda to destroy the red colouration. The cask is brushed vigorously or a chain is inserted and the cask moved around. This treatment is repeated and after a final rinse the cask should be quite safe for the reception of cider.

(*f*) *Sulphuring of Casks and Vats.*—For very large vats the desired cleanliness can be obtained by producing sulphur dioxide gas by the burning of sulphur in a small metal cup inserted through a suitable opening. As soon as combustion has commenced, the vessel is closed down. The theoretical quantity of sulphur necessary is about 9 gm. ($\frac{1}{3}$ oz.) per 100 gallons of space, this weight producing twice its weight of sulphur dioxide. In practice there is an appreciable loss, so the theoretical quantity should be increased.

Small casks can be treated with sulphur matches, beneath which are small catch pots to prevent the sulphur falling into the cask and introducing a taste to the cider which is reminiscent of rotten eggs or sulphuretted hydrogen. It is probably better to use liquid sulphurous acid for this purpose.

It should be remembered that sulphuring is not effective unless the cask is first very well drained. If any considerable amount of moisture is present, the sulphur dioxide is oxidised rapidly to sulphur trioxide, which because of its affinity for water, will form sulphuric acid and will not inhibit the growth of organisms. The permanence of the sterilising effect of the sulphuring of casks will depend on the humidity of the atmosphere and the temperature. A damp locality or a dry atmosphere induces the loss of sulphur dioxide and the moisture fosters the development of mould spores.

TRANSLATOR'S ADDENDA

The modern method of treating concrete tanks with bituminous linings has to a large extent obviated the need for cider-makers to treat their own vats, etc., with silicate or other substances. Linings containing bitumen, however, must not be sterilised by steam and in these cases sulphur dioxide is widely used. Metabisulphites or bisulphites are not suitable for this pose, and a 2% solution of sulphur dioxide (prepared from saturated solution of the gas in water) should be used. pochlorites are also in common use, some of these being trically prepared and having high bactericidal powers. The cedure of burning sulphur in casks and vats is now practically olete. A modern English cask washer of the Macardles type l made by Geo. Adlam & Sons Ltd. is shown in Fig. XX. e more intensive scouring of a badly soured cask can be dertaken by the use of a Beare mechanical cask chainer g. XXI).

CHAPTER IX

PRELIMINARY PURIFICATION OF THE JUICE (INCLUDING KEEVING)

BEFORE the main fermentation process is allowed to commence, the juice should be subjected to a form of purification which removes insoluble materials held in suspension in the liquor; in addition to which, certain pectic compounds which are in a suitable state to be easily thrown out of solution should be simultaneously removed from the juice.[1] This purification is effected either by mechanical, chemical or biological means.

Juices from sweet apples should always undergo this form of treatment for they are naturally prone to form deposits and are always more or less conspicuous for their pectinous constituents. Juices obtained by the diffusion method and those from apples with acidities above 0·55% malic acid can be allowed to undergo the main fermentation process without this preliminary clarification or keeving process.

The purification process with which we are now concerned is important from the point of view of the later life of the cider. A juice that has been so treated will not only become clear, but, what is of much greater importance, it will be freed from a very large proportion of its micro-organisms. The organisms causing maladies and disorders are removed to a great extent and the juice is recovered in an ideal form for true fermentation and to give a cider of quality and sound keeping properties.

Five methods are available for attaining this preliminary removal of chemical and biological materials:

(*a*) Simple straining
(*b*) Centrifugation
(*c*) Filtration
(*d*) Fining
(*e*) Spontaneous, natural clarification or keeving (defecation)

This last method is of the utmost importance, and is often wrongly referred to as 'turbulent fermentation'.

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[1] The process is known in French as 'épuration' and has no direct English equivalent.

Straining

ll juices should be strained immediately after they run from press so that they can be relieved of solid materials, such as p, skin, stalks, seeds, etc. The sieve can be composed either orsehair or of a metal sheet suitably perforated for the ining of the juice.

Centrifugation

The Sharples supercentrifuge was first used by Warcollier fresh apple juice in 1922 (see Figs. XLVIII and XLIX). e machine then rotated at a speed of 36,000 r.p.m. and in rcollier's laboratory it was shown that it was by no means nsistent in producing clear juices (Warcollier: *Studies in un- ble ciders*, Congrès pomologique de Quimper, 1922—*Bulletin ociation française pomologique*, 1922).

In 1926, Warcollier continued his experiments with the same ke of machine for the treatment of fresh, sweet apple juice. e centrifuge was a large commercial instrument, completely closed, and the juice, during its passage through the bowl, s protected from air contact by a stream of carbon dioxide s. Warcollier reported that the centrifuge did not produce immediate clarification of the juice. It remained cloudy as ssued from the outlet, and it was only several days later that e deposition of pectin materials led to a noticeable clarifica- n in the juice. The conclusion was reached that centrifugation celerated the onset of pectin precipitation.

Filtration

It is quite impossible to consider the commercial filtration of eet juices as they run from the press, but filtration can be plied to sharp and medium-sharp juices as well as to those ices which are produced by the diffusion method.

Pulp filters are most suitable for this purpose. The pulp fibres, art from mechanically entangling the solid particles in the ice, have the additional property of adsorbing on their surface any colloidal materials such as pectins.

Fresh juices can also be filtered in closed vats fitted with a lse bottom on which is laid a thick paste of cellulose pulp. A w pressure of 2-3 lb./sq. in. is needed. Juices that have been filtered in this way ferment more slowly than unfiltered juic and afford less voluminous lees during the fermentation.

Filtration is to be recommended at this stage of the cide making operations provided that it can be done withou aeration with consequent acetification of the juice. As a larg proportion of the colloidal and pectic substances are retaine on the pulp, the subsequent keeving process furnishes only a insignificant brown head. The process eliminates all foreig organisms, which is in itself an extremely valuable contributio to the later, sound processing of the cider.

Fining

Louise has suggested the treatment of fresh juices with vario fining agents so that clarification can be assured both in th fresh juices themselves before fermentation and also in the ult mate fermented products. He recommends the use of calciu phosphate or isinglass, the former at the rate of 0·15% (1½ l per 100 gallons), the latter at 0·005-0·01% (¾-1½ oz. per 1 gallons). Louise also added chalk and phosphoric acid to th juice to produce a precipitate of the calcium salt. It is claim that the ciders so produced remain clear when bottled, but must be pointed out that they will also be practically colourle Warcollier was not satisfied that the process, on a commerc scale, gives as good results as Louise claimed for it, and hen it must be treated with considerable reserve.

Spontaneous Clarification (*Keeving*)

Freshly pressed apple juice placed in an open vat in a cel will show on its surface after a few days a brown scum the colo of gingerbread; this will indicate the commencement of a ve slow fermentation; many bubbles of gas rise to the surface a burst in the brown scum producing a characteristic sour simultaneously with all these proceedings, the juice in the bo of the cask becomes clear. A process of defecation,[1] or spo taneous clarification has occurred in the juice. Part of the pec has been precipitated by the natural enzymes in the juice, a this precipitation has itself caused a clarification of the ent bulk of juice by the removal of insoluble substances in the fo e brown head. The physical chemical purification under- by the juice in this process is accompanied by microbio- al changes which leave the juice practically devoid of all yeasts and organisms that are responsible for disorders.

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[1] The nearest English equivalent to the French term 'défécation' is 'keevi and this word will be used henceforward in this connexion.

arcollier (Pomological Congress, Laval, 1906) has studied process in very great detail, and much of the information is chapter is due to his own work.

o achieve this purification of the juice, it is necessary to ice a clarification for the following reasons:

) to precipitate part of the pectins in the juice.

) to produce a withdrawal of the coagulum so formed.

) to induce a very slow fermentation with consequent for- ion of top and bottom layers of insoluble materials.

efore proceeding to the practical considerations involved, necessary to state the theoretical bases on which the process s.

ccording to Frémy (*Ann. de phys. et chimie*, 3rd series, XXIV, , 1848), 'pectic fermentation' is due to the action of a natural yme, pectase. The pectin is precipitated as an insoluble cal- n salt. The action is dependent on the relative proportions he enzyme, calcium salts and the free acids of the juice. ds inhibit the action (Bertrand and Mallèvre: *Comptes Rendus*, IX and CXX, and *Bull. Société chimique*, 1894), whilst the ition of dicalcium phosphate to apple juice aids the removal ne pectic substances (Louise, Société nationale d'Agriculture, y 1901).

Varcollier has also made the following observations:

i) The natural tannins of the juice inhibit the pectic pre- tation.

ii) Aluminium salts in certain doses have a favourable effect al to that of calcium salts.

iii) In the insoluble calcium salts formed in the pectic fer- ntation, the percentage of calcium is never constant. Hence, process cannot be visualised as a single, clear-cut chemical ction with calcium pectate as its sole end product.

iv) Other calcium salts have an effect on pectin precipita- , e.g. calcium saccharate.

v) It is dangerous to employ excessive doses of defecating nts for the precipitation of pectins; such added materials often denature the cider, and give rise to bitter, earthy and other unpleasant tastes (e.g. a 'raspberry' flavour is noted o occasion).

(vi) In actual practice, it is not safe to allow more tha 300-400 mg. of calcium or aluminium per litre to remain i solution after the clarification process.

Warcollier has summarised a further study of the subjec under the following headings:

(*a*) For each variety of fruit, there is a definite state of maturity at which the removal of pectin occurs most rapidly an effectively.

(*b*) This degree of maturity varies each year with the climati conditions, the siting and health of the trees, nature of the soil and quantity of pectase present.

(*c*) It appears to be easier to obtain the required clarificatio by keeving when working with mixed varieties of apples tha with one single sort.

(*d*) In any given set of conditions, one can arrive, by tria and error, at the correct blend of apples, the right soil, th optimum maturity to provide the conditions for natural defecation in the juice; i.e. without any chemical addition.

(*e*) In the large cider factory, which must perforce cater fo random mixtures of all sorts of varieties of apples, keevin generally needs to be induced by some chemical addition.

Practice of Keeving

The process involves four separate stages:

I. Precipitation of pectic substances in a completely sti juice.
II. Separation of the precipitated materials.
III. Induction of a very gentle fermentation to ensure th formation of the brown head and the lees, and consequently to aid the ultimate clarification of the cide
IV. Racking away the clear juice from between the head an the lees.

These conditions can only be achieved by paying close attention to the following three sections.

I. The prevention of fermentation during the initial stage the processing can only be ensured by maintaining the juice a a temperature slightly above freezing point. On no accoun should it rise above 6-8°C. For this reason, it is better to appl

process only in cold weather when the outdoor temperature
bout 4-5°C. Juices made in October and November do not
fy so well as December-made juices. Warcollier has even
rved in some cider factories that all early ciders were very
r in quality because of the relatively high temperature which
vented the formation of a brown head, showing instead a
te head which can always be taken as a sign of poor defeca-
or keeving. In such circumstances, the cider-maker should
e such steps as are possible to avoid high temperatures. The
les should be exposed to the night air, or washed in very
d water; the milling should be carried out early in the morn-
, before the day reaches its greatest heat. Such treatment
bring its own reward for the efforts expended—the juices
clear well and a brown head will be produced.

Cider-makers who work intermittently should choose cold
s for their milling operations, although they should avoid
occurrence of temperatures below 0°C. in the factories
mselves.

The larger maker, who is obliged to mill his fruit day after
without intermission to complete his programme, must
id appreciable alteration in temperature in the juice; other-
e it will be impossible to control his production, clear and
udy products being made according to the effect the tem-
ature conditions impose on his processing. It is most desir-
e that he should be in a position to cool the juices once they
ve been collected from the presses.

This may be achieved by storage in naturally cool cellars or
artificial refrigeration. If, however, no means of cooling the
ce are available, some control is possible by the use of sulphur
xide, added in the liquid or gaseous form. The gaseous form
ntroduced in the juice by burning sulphur in the vats pre-
us to the reception of the juice. The method is only approxi-
te and very variable results will be obtained.

Liquid sulphur dioxide is more satisfactory. A sulphitometer
be used to measure the exact amount of sulphur dioxide
eded to introduce a given dose into the juice. Calcium bi-
phite is not recommended because of its instability. Potassium
tabisulphite is a preferable compound if stored under cool,
conditions. It contains half its weight of sulphur dioxide.

One general criticism of sulphur dioxide in any form is that its effect varies from juice to juice. The same addition of pr servative will prevent any fermentation in one juice for sever days, whilst in another juice active fermentation will commen within twenty-four hours. In very small doses, sulphur dioxi can act as yeast accelerator and exert the very opposite effe to that which is naturally expected of it.

The general antiseptic effect of sulphur dioxide varies wi the state of the preservative in the juice (i.e. whether free fixed), the nature of the juice, the relative number of yeast ce present, the activity of the yeasts and their power of acclim tising themselves to sulphur dioxide. For these reasons, the u of a standard dose of sulphur dioxide (say 80 p.p.m.) will n give such generally acceptable results as the employment of lo temperatures. (In this connexion, it should be noted that th maximum dose of sulphur dioxide allowed by law in Fran is 200 p.p.m.)[1]

Despite its many advantages, the addition of sulphur dioxi to fresh juices to enable the keeving process to be successful terminated is valuable where low temperatures cannot be e ployed. The usual dose of sulphur dioxide is 50 to 100 p.p.

If limited cooling facilities are available, then the combinati of moderate cooling with small doses of sulphur dioxide is acce table as an alternative to really low temperatures.

II. The spontaneous coagulation and precipitation of so part of the pectic compounds in the juice is affected by ma factors such as the physiological composition of the appl their state of maturity, etc. Only in cases where the pec changes do not occur naturally in a sufficiently quick peri is it allowable to induce such a coagulation by the addition certain salts or of juices specially chosen for their richness pectic enzymes. The best salts for the purpose are dicalciu phosphate, calcium saccharate or calcium carbonate. The ad tion of each should be such that the calcium content of t juice should not exceed 300-400 p.p.m.

It has generally been considered advisable to add 1½ lb. calcium phosphate per 100 gallons, but Warcollier regards t as being too heavy an addition, leading possibly to a bitter ta or to extraneous flavours (i.e. raspberry). The phosphate h the disadvantage of forming phosphoric acid, the phospha le of which activates the yeasts, which is not helpful for production of naturally sweet ciders.

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[1] This is similar to the British regulations.

rther, commercial dicalcium phosphate often contains the uble tricalcium salt, the presence of which should be ded at all costs. Calcium carbonate, too, is open to the objection unless suitably pure materials are purchased. n this point of view, calcium saccharate is the most suitable

lb. of sugar are dissolved in 7½ gallons of water, and 4 lb. uicklime are suspended in 2 gallons of water. The milk of is added to the sugar solution and is well mixed, the volume g ultimately adjusted to 10 gallons. An analysis will indicate percentage of calcium in the saccharate and the amount to This will approximate to ·4 pint per 10 gallons of juice to reated.

he saccharate will slightly lower the acidity of the juice, after defecation this should be adjusted by adding 8 oz. 100 gallons of tartaric acid, the maximum dose permitted aw.

he sugar used in the manufacture of the saccharate is re-ered in the juice and is fermented to alcohol during the r fermentation process.

artaric acid in association with lime or chalk is a useful cant. Good clarification is achieved and the retention of ur is satisfactory. The optimum amounts to add are 50 ts of acid to 20 parts of lime, or 50 parts of acid to 33 parts halk. The acid should be added to the juice separately and re the calcium salt.

Varcollier has indicated, as a result of work carried out in 1 (*The Keeving of apple juice*, Congrès de la pomme, Rennes, ember 1921) that it is an advantage to add the clarifying erial to the pulp as it leaves the mill and to allow the ted pulp to remain for a certain period before pressing it. s procedure ensures the intimate contact of all the pectic pounds of the apple both with the enzyme system of the t and the added defecant which has an additional effect the pectins. If the defecant is to be added to the pulp, one uld choose calcium saccharate (each gallon of saccharate tains 6½ oz. of lime). The dose should never exceed 2¼ gal- of saccharate solution per ton of pulp.

Tartaric acid should be used to increase the acidity after th clarification process (4-8 oz./100 gallons).

The enrichment of certain juices with pectase enzymes can b produced by adding certain pear juices. This procedure is common one in Switzerland where the juices are known 'scheidmost'. An alternative method, when the necessary mate ials are available, is to macerate the juice for several hours wit the sound, clean pomace from the processing of pears.

Kayser and Delaval have shown that an extract of growin or germinating barley can activate the coagulation of pect compounds in apple juice because of its high enzyme activit The extract is employed in a concentrated state, but as it also a rich source of nitrogen, the dangers of acceleratin the yeast action are so real that the use of barley is n advisable.

III. The next stage in the process is to induce an extreme slow, continuous fermentation in the juice. If the juice has bee maintained at a temperature of 4-6°C., or if a suitable dose preservative has been added, fermentation will commence spo taneously and will lead naturally to the formation of a brow head after several days. There can be no doubt that this is t best procedure for obtaining quality ciders. If the onset of fe mentation is delayed too long, the temperature of the jui should be raised by 1-2°C., if this is possible. If the process h been carried out in vessels incapable of receiving addition heat, then one must wait a few days longer so that fermentatio may commence. The artificial heating of the premises in whi the juice is stored is a dangerous procedure, for it often lea to an excessive and uncontrollable fermentation.

There is little need to fear the effects of a fermentation th starts very slowly and continues at an excessively slow ra The defecation period will be lengthened, but its efficiency w not be compromised. Excessive fermentation at this stage w lead to the formation of a white head, and provide a poor clarified juice that will retain its thick and cloudy nature.

Again, the addition of yeast with ammonium phosphate is be deprecated because of the possibility of the ensuing ferme tation becoming unmanageable.

The formation of a white head can be due to a number different factors:

The juice comes from the press at too high a temperature, ng to the commencement of fermentation before the pre- ation of pectic substances is complete; the surface of the is covered with a white foam, the juice remains opaque, the resulting cider will possess only poor qualities of taste, ma and stability.

) The pectic precipitation is satisfactorily achieved and a n head commences to form. The temperature rises rapidly a vigorous fermentation ensues. The brown head disappears is replaced by a white foam.

) The pectic precipitation is satisfactorily completed, a n head commences to form, but the temperature falls dly. The fermentation process is arrested and the brown d, no longer supported by the gas evolved by the yeast vity, falls through the juice and disintegrates on the bottom e container. Should the fermentation recommence, a brown d will be formed but it will be lacking in coherence and will ccompanied by a white head.

) Sudden, appreciable changes in barometric pressure may to similar occurrences to those referred to above.

hen one or other of these eventualities occurs, immediate s must be taken to regularise the position. In the first place, juice should be cooled and carefully racked without aeration another vessel which has been previously sulphured. ondly, certain materials may be added which have the power oalesce the broken portions of the brown head into an un- ken whole. White of egg, pure milk casein and isinglass are e recommended for this purpose. Cooling of juice which is dangerous state can be effected by circulating cold water ough the vessel by means of a coil, or by immersing in the e vessels containing ice.

he microscopic examination of the white and brown heads ls to some interesting observations.

he brown heads contain inert materials, such as cell debris, ch grains, numbers of living organisms, yeasts of all types sizes (filamentous, elongated, ovoid, spherical and lemon- ped); wild yeasts, apiculate yeasts, and true cider yeasts; uld spores and mycelia; and, finally, bacteria and cocci of ious types. It is easy to appreciate from this list how the for- ion of a brown head operates a virtual biological purifi-

cation of the fresh juice. Warcollier has isolated from brow
heads in cider factories sarcina, large bacilli, cocci and a ba
teria, all these organisms being operative in causing vario
disorders of cider. A clean, sound cider has been acetified in
few days by inoculating it with a few organisms taken from th
brown head of a cider, and the same phenomenon has bee
noted even in closed bottles which were free from air co
tamination.

The white heads also contain the same organisms but th
are especially rich in apiculate yeasts. It would seem that the
yeasts, which always develop during the first days of natur
fermentation in a juice, are partly the cause of the formation
a white head, since they can provoke suddenly and rapidly
fermentation which is prejudicial to the fabrication of a goo
cider. These organisms have a nuisance value greater than an
positive properties they may possess.

A cider that forms a white head is destined to develop o
or other of the various disorders that can be due to organism
which are left in the juice. The white head is merely a foam
without substance or weight and in this respect is in striki
contrast to the brown head, whose formation exerts such wid
spread influence on the future behaviour of the cider.

Vessels for Keeving Process

Many forms of container may be used for the spontaneo
clarification of fresh apple juice, but the depth of the jui
should be between 2½ and 3¼ feet. The vessels can be open
closed; in the former, the progress of clarification and head fo
mation can be followed visually, although the contact of th
surface of the juice with air necessitates the completion of t
process in three or four days. The closed vats reduce acetific
tion and produce a slower defecation, but the entire proc
should be completed within six days. Smaller makers use vess
varying from 100-400 gallons capacity, which they fill to with
4 inches of the top. One procedure in common use is to lea
a free space above the juice so that the whole of the brown he
remains in the confines of the vat. This is referred to as 'inter
head formation'. Sometimes a relatively small space is left,
that a part of the top deposit is ejected from the vat. The th

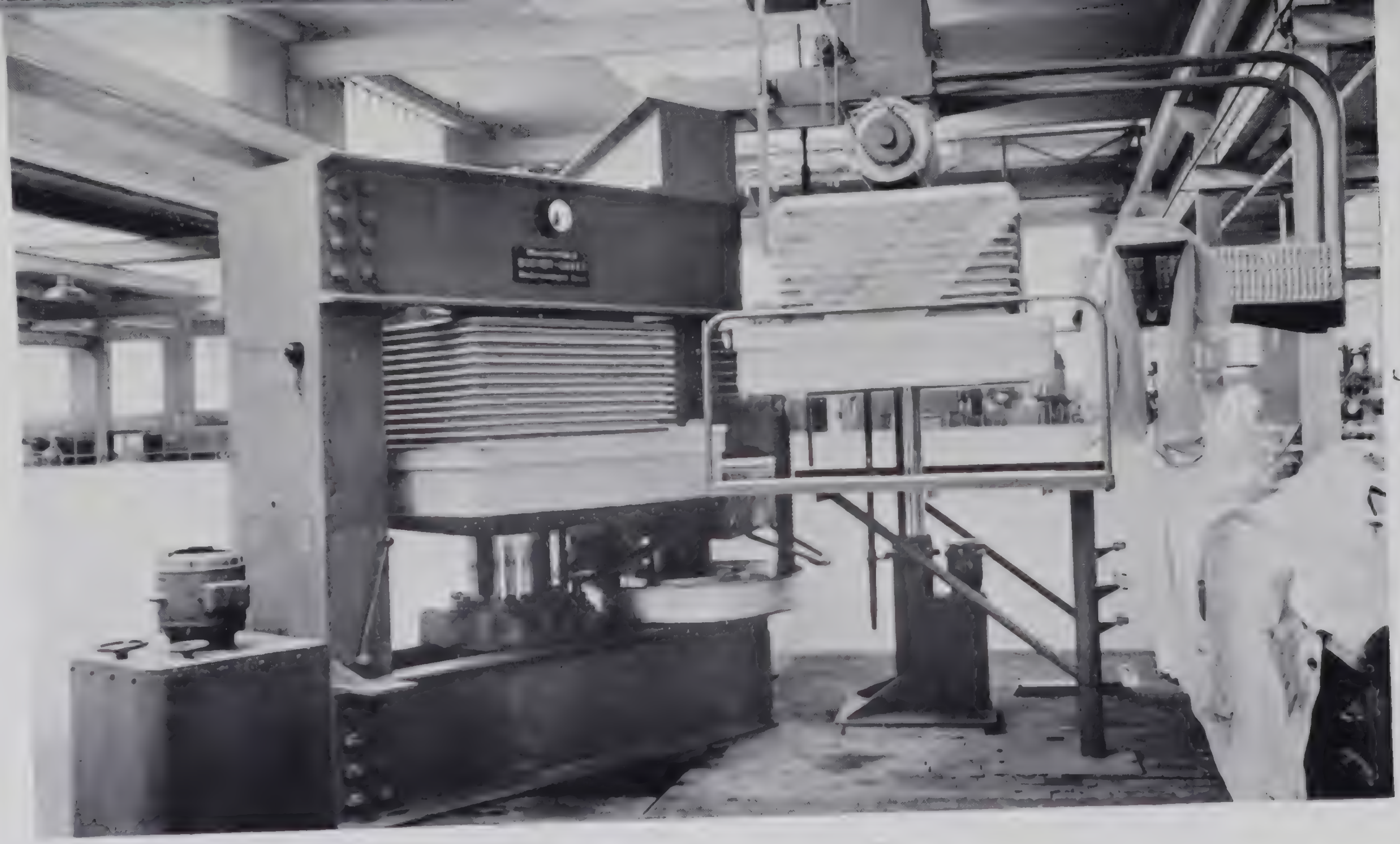
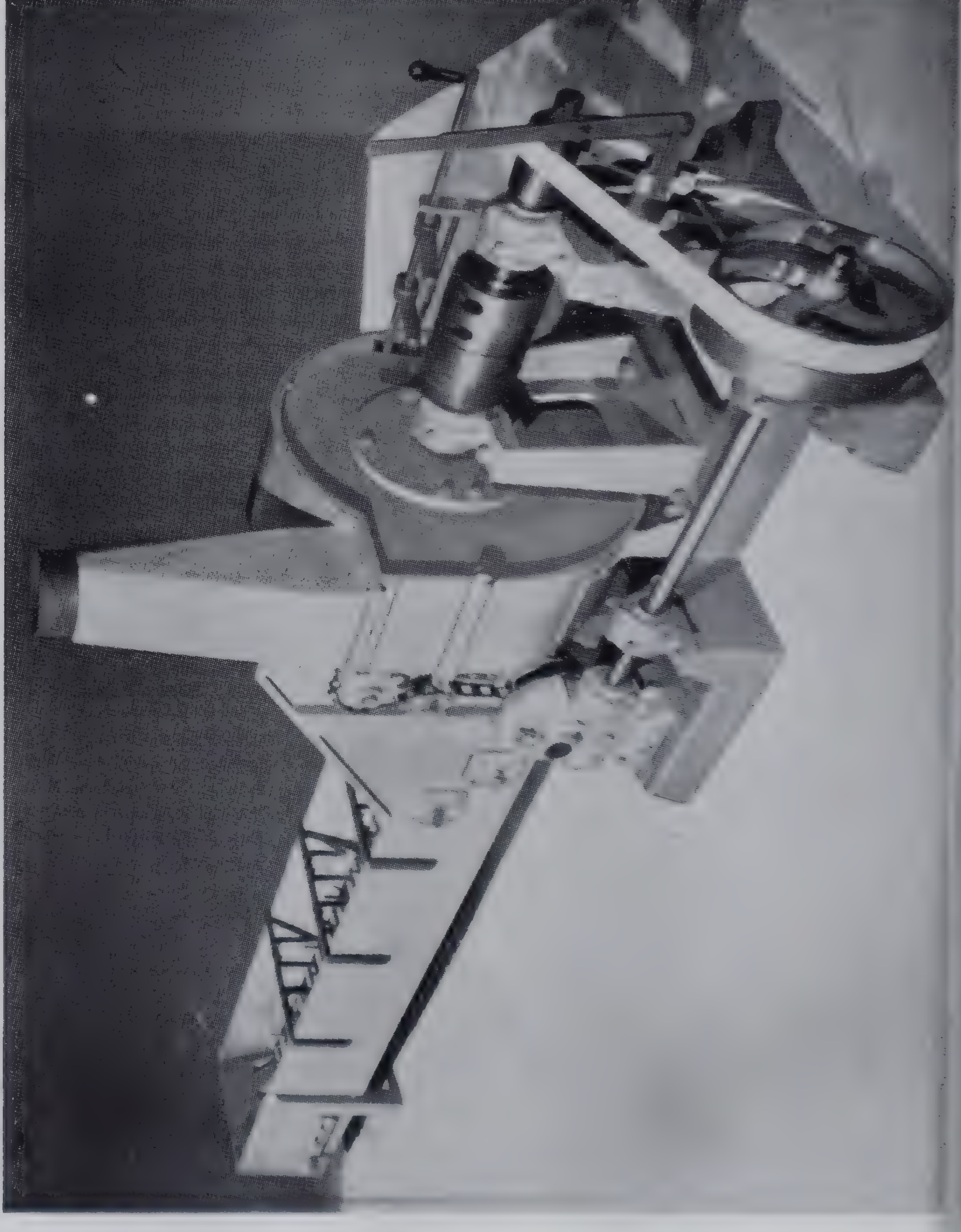


Fig. XVIII. Swiss Bücher-Guyer Press



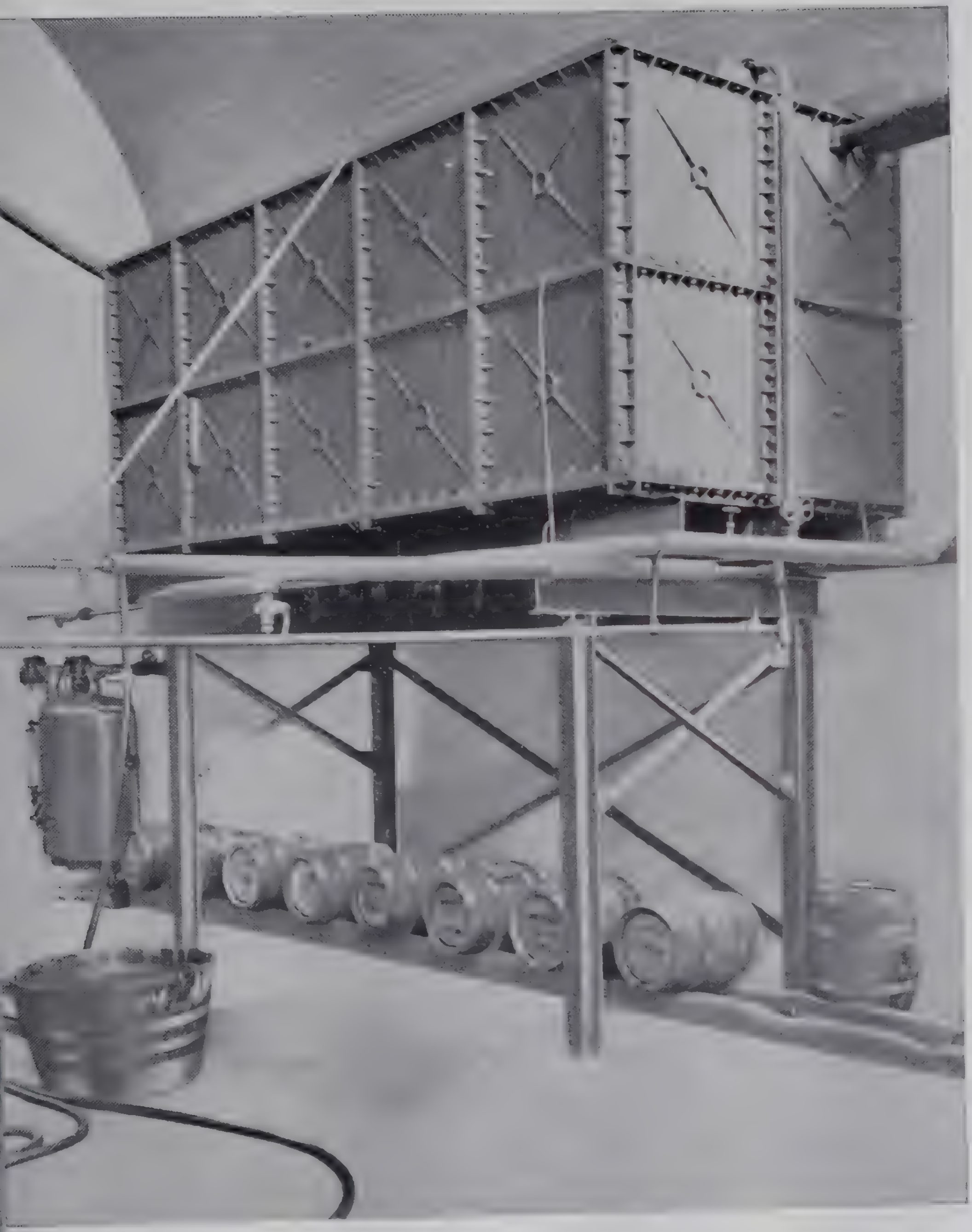


FIG. XX. Macardle's Cask Steaming and Rinsing Apparatus

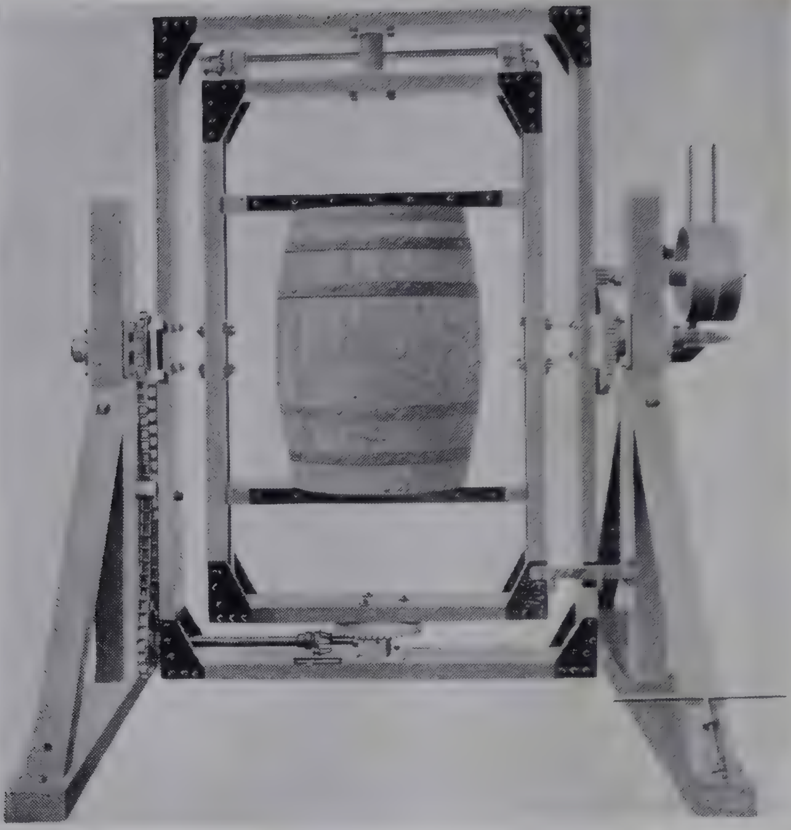


FIG. XXI. Beare Mechanical Cask Chainer

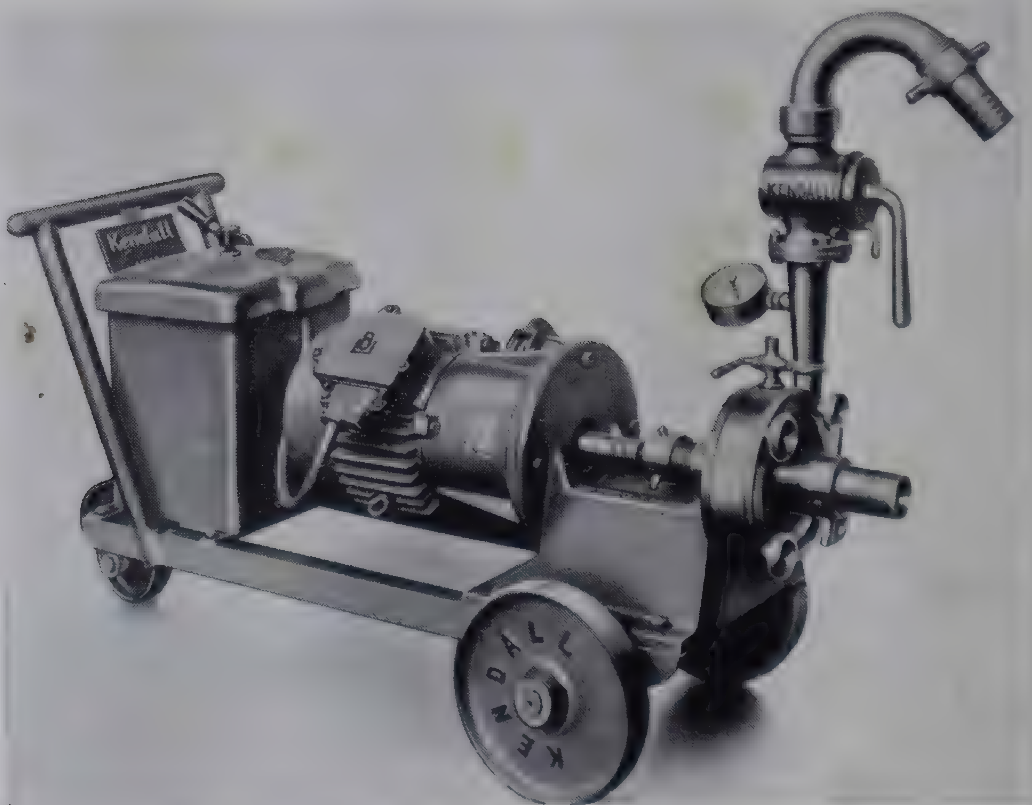

Kendall
KENDALL
KENDALL

FIG. XXII. French Cider Pump (Kendall Type)

rnative is to fill the vats to the brim (exterior head expul-
) so that the head is totally ejected.

he flocculent material comprising the head will fall over
outside of the vats, and the exterior walls should be washed
sterilised to prevent infection arising from the putrefaction
fermentation of the solid materials which would otherwise
on to the walls.

ecause of the difficulties which are attendant on the process
completely filling the vats, Warcollier prefers to allow the
d to form inside.

or large factories, square or rectangular vessels 3 ft. deep
recommended. These can be filled to a depth of 2 ft. 6 in.
h juice. Such vats can be closed, but an opening should be
in the top, about 1 ft. 6 in. square, through which to observe
state of the juice within. The vats should be slightly pyra-
dal in section. They should be fitted with a draw-off cock
lf-way down for sampling purposes. The lower half has pro-
ion made for a large sized cock to withdraw the clear juice;
s should be placed about 5 in. from the bottom of the vat.
e removal of the lees should be provided for by a cock in the
ttom of the vessel, which should slope towards it. The vats
usually made of cement and are covered with a lining of
table efficiency. In view of the importance of the process, the
ts should be installed in a special room, separated for the
rpose; the closed vats, however, can be used for the storage
cider after the making season, if the large square vent holes
provided with air-proof seals.

Size of Keeving Vats.—Small factories should install vats with
pacities from 100-400 gallons. Large cider-makers often in-
ease these sizes to 4,500 gallons, where the depth of the vats
6-9 ft. Such vessels are too large for dealing safely with the
ce. Should the keeving process not be successful, the volume
juice which will need very careful treatment is appreciable
d will cause serious dislocation of routine in the factory. The
lume should never exceed 2,200 gallons. These vats should be
ed in a single day as the addition of further quantities of
ce on the following day would compromise the success of the
eving process.

Duration of Keeving.—This will be a very variable period.
me French juices from chosen varieties at full maturity will

clarify in 48 hours; others need 3-4 days. No arbitrary rule can be given for the time in which any given juice will form a head of the desired consistency; only experience with the same apples over a period of years will enable a forecast to be made with any certainty. Any one of the phases of the complete process may commence before the preceding stage is fully completed. A juice that is ready for racking in 48 hours is a case in point. Fermentation commences the moment the juice leaves the press, but the precipitation of the pectin compounds may be so rapid that the formation of the brown head will be coincident with the commencement of fermentation.

Finally, the success of the process is bound up with the slight fermentation needed to form a coherent head. Consequently, the term 'turbulent fermentation' (as is often used in France) should not be used in this connexion. It does not truly express the fundamental ideas underlying the process and its use can only lead to misconceptions of the basic principles involved in the process.

Racking

Should the keeving operation have been successful, a time will come when the head is well formed, the lees are deposited, and the yeast is forming carbon dioxide gas at a very slow rate. The cider between the two deposits will be clear. This is the precise moment at which to rack the clear cider away from the head and the lees. To leave the racking a day or two longer will prejudice the process, as the increased rate of fermentation will cause the cider to lose its clarity and the head will disintegrate. Even changes in barometric pressure can upset the clarity of the liquor at this stage. The specific gravity of the juice cannot give any guidance as to when racking should take place.

Racking is an indispensable feature of cider-making. It removes a large proportion of the yeasts and wild organisms entrained in the head, and prevents a main fermentation which will later become excessive. The process should not cause aeration of the juice nor bring it into contact with iron, zinc or lead. Various methods are employed for racking.

Crude Racking.—A pipe leads the juice from the region between the head and the lees and the juice is poured into a clean k through a funnel filter with a tube leading to the bottom the cask.

Siphoning.—When two levels in the factory are available, a hon tube can be used. The lower end of the tube should ach to the bottom of the cask to be filled to avoid aeration. glass insert in the siphon tube is valuable as a means of ascer- ining when the clarity of the juice commences to lose its iginal brightness.

Mechanical Pumps.—Pumps are very widely used in all fac- ries. They should possess a simple mechanism and be capable being taken down and re-assembled quickly. Piston pumps ith single or double action are very effective, especially the tter which gives a constant flow. Vane, gear and centrifugal umps are all available. The last mentioned can be used for ices and ciders that retain considerable amounts of solids.

A modern Kendall pump is shown in Fig. XXII.

Racking in Carbon Dioxide Gas.—The juice can be blown to a ask at a high level by the use of a slight top pressure of carbon ioxide applied to the full cask. A pressure of 3-4 lb./sq. in. is ufficient for the purpose. The use of carbon dioxide enables ne maker to fill the receiving cask with gas and thus avoid all ontact with air.

Utilisation of the Lees

The lees represent about 8-10% of the total volume of juice. hey should be transferred to a special vessel, allowed to erment completely, and then distilled. In large factories it is ossible to filter the lees, in which case the product can be ermented in the normal way. Warcollier has studied the use f special apparatus for this purpose, but with little success. he price of the plant and its running costs are greater than is arranted by the return of juice obtained.

Translator's Addenda

Keeving

This process is still very widely used in France, and although he term and the process originally associated with it have be- ome less familiar in England in the last twenty years, many

English factories adopt what is practically the same process for the production of high quality ciders. The usual method is to pump the fresh juice to a series of vats at the top of the factory, and rack first the juice, and later the cider, from the top and bottom deposits into vessels at a lower level. This process becomes merely a series of controlled rackings which retard the rate of fermentation and improve the quality of the cider.

Very scant attention has been paid to the process in recent years by research workers, and the only direct reference to it in English literature is by Charley (1) who examined the possibility of keeving juices at low temperatures, following a procedure which originated in some large French cider factories. Freshly expressed juices were maintained at 9°C. and 2°C. for 7 days with the intention of throwing out of solution those materials that would be soluble at normal temperatures. The best clarification was achieved in juices that contained the highest amounts of pectin; the lower temperature gave superior results to storage at 9°C., and certain culinary types of juice exhibited remarkable clarification effects at 2°C.

Pumps

The older types of semi-rotary hand or mechanically operated pumps for the movement of cider within the factory are still to be found in very many cider-making installations, but several newer types of pump have been introduced during the past twenty years. It is not possible to refer here to all makers of pumps, or even to all types of machines, but reference is made to the Mono Pump and a special type of stainless steel pump produced by The A.P.V. Company Ltd.

The construction of the Mono Pump is as follows: A single rotor, rolling in a fixed stator, constitutes the essential mechanism. The stator, which is normally of rubber, has the form of a double internal helix and the rotor is also of helical form, but with a single scroll and with half the pitch of the stator. The rotor maintains a constant seal across the stator and the two elements engage with one another in such a way that this seal travels continuously along the stator, producing a uniform and positive displacement.

Fig. XXIII shows a D3 Mono Pump removing fresh juice from the well of a cider press in the Devon factory of Messrs.

nplim Ltd., manufacturing a concentrated apple juice for
cialised purposes. In the same photograph can be seen the
cess of feeding freshly milled pulp direct from the mill to
cloths by means of a D6 Mono Pump, which is separately
tured in Fig. XXIV. The pumping of apple pulp has only
n introduced in very recent years and is particularly con-
ient in cases where the usual alignment of mill and press for
ect feeding of pulp into the cloths is undesirable or impos-
le. Some Continental factories mill the fruit on the ground
or and pump the pulp to a higher floor for pressing. A by-pass
n be fitted by which the pulp can be returned to the reception
sel under the mill when the cheeses are not being fed.

Fig. XXV shows a D3 portable Mono Pump used for racking
nditioned ciders at the factory of Messrs. Evans & Ridler Ltd.,
ereford. The process is effected without aeration and a non-
lsating flow is regularly achieved. The use of this unique type
pump has many advantages wherever liquids or milled pulp
ve to be moved in the cider factory.

Figs. XXVI and XXVII illustrate the external and internal
rangements of the latest type of pump for potable liquids de-
gned by The A.P.V. Company Ltd. The pump is constructed
om stainless steel and is extremely easy to dismantle for clean-
g—a most important feature in connexion with the main-
nanace of sterility in cider plant.

REFERENCE

(1) Charley, V. L. S., *Ann. Rept. Long Ashton Res. Sta.*. 1935, p. 138.

CHAPTER X

YEASTS AND THE FERMENTATION PROCESS

THE ensuing chapters dealing with the remaining processes in the making of cider are concerned with the action taken

(*a*) to prevent access to the juice or cider of undesirable organisms
(*b*) to inhibit the development of disorders from specific organisms always resident in the juices, and
(*c*) to obtain as perfect an alcoholic fermentation as possible.

Alcoholic fermentation is the process of the degradation of sugar into alcohol and carbon dioxide. This breakdown of sugar is due to the development in the fermenting medium of a particular type of organism or yeast.

The chemical representation of the formation of alcohol and carbon dioxide is expressed by the following equation:

$$\underset{\text{glucose}}{C_6H_{12}O_6} = 2\,\underset{\text{alcohol}}{C_2H_5OH} + 2\,\underset{\text{carbon dioxide}}{CO_2}$$

Translated into quantitative terms, the equation shows that 180 parts of sugar form 92 parts of alcohol and 88 parts of carbon dioxide. As a very close approximation, it can be said that 100 parts of sugar provide 51 parts of alcohol and 49 parts of carbon dioxide. In actual fact, the process of sugar breakdown is less simple than indicated in the above equation. For each 100 parts of sugar lost during the process, 3-8 parts of glycerin and 0·6-0·8 parts of succinic acid are formed at the expense of the alcohol, whilst smaller percentages of aldehydes, higher alcohols, volatile acids and ethers are simultaneously produced; some sugar is expended on increasing the weight of the yeast.

Yeast

Yeasts are microscopic organisms in the vegetable family, belonging to the order of the *Ascomycetes*; their size is approximately that of a corpuscle of human blood, i.e. $\frac{5}{1000}$ - $\frac{10}{1000}$ of a millimetre ($\frac{1}{5000}$ - $\frac{1}{2500}$ of an inch) in diameter; expressed in ther way, one can say that 2,500-5,000 yeast cells placed to end would represent 1 inch in length. Yeasts of any one e vary in diameter between 5 and 10μ (the Greek letter μ ng the measure used in microbiology to represent 1/1000 of m., or 1/25,000 of an inch; it is known as a micron). Yeasts ve various forms, such as spherical, oval or elliptical. Gener- y, they are composed of living cells, each comprising an outer face of cellulose material, enclosing a protoplasmic liquid d a nucleus. The protoplasm alters its appearance as the cell comes older; in the young cell, the liquid phase is homo- neous throughout, but as the cells age or are damaged, the toplasm becomes filled with granules.

A yeast generally reproduces itself by budding. The organism bserved to develop a swelling which gradually becomes more onounced until the bud is practically as large as the parent l. Each of these two sections is now capable of producing a ther cell, whether it remains as one unit or whether it sepa- tes. Yeasts which remain in connected groups are known as p yeasts'; those that separate as 'bottom yeasts'.

Multiplication of yeasts is very rapid. One cell can, by divi- n, produce a further cell each half hour, so that at the end of hours the number has reached more than 4 million. Yeast owing in a sugary medium will reproduce itself by budding ovided that it is supplied with the other nutrients necessary r its development.

Yeasts are also reproduced by means of endogenous spores hich are actually the fundamental way in which the species is eserved. Yeasts form spores when their food requirements are nied them. Spores are capable of resisting all adverse con- tions and in this form they pass through the winter in the chard soil or in the cider-making buildings. They are dis- minated throughout the orchards and on the surfaces of the ples in the following summer and autumn by wind, insects d animals, but do not really become abundant until the fruit comes fully ripe. They then inoculate the juice as it runs from e milled apples. In cider apple districts, the same yeast types e found from year to year and become adapted to the climate d to the juices from the fruit. The same races regularly pre- ominate and this phenomenon results in what may be regarded a natural selection of cider yeasts.

Factors Affecting Yeast Activity

Temperature.—Yeasts are very susceptible to varying temperatures. Below 5°C., yeast action is considerably retarded; a 0°-2°C., activity is generally completely suspended; at the othe end of the scale, yeasts develop with optimum speed betwee 20°-25°C., but above 38°C. the metabolism of the cells is affected and they become inactive. These temperatures are not to b too literally interpreted, for they vary with the types and specie of yeasts, as well as with the same yeast according to its capacit for acclimatisation.

The actual temperature at which the fermentation proces proceeds will alter the nature of the final product: for example a pure apple juice fermented with its own natural yeast at 10°C will produce a sweet cider with a fine aroma; fermentation a 18°-20°C. gives a completely dry cider in 15-20 days, but th final product is suitable only for distillation; at 32°-34°C. th process extends over only 48 hours, but the poor quality of th end product necessitates its use for the production of neutra alcohol.

At very low temperatures, such as 200°C. below zero, th yeast is inactivated but is not killed. Yeast in a moist state ca be killed by exposure to temperatures of 60°-65°C. for 15 minutes, or, if the yeast is dry, to temperatures of 100°-105°C From this data, it can be deduced that when it is necessary t kill yeasts in apple juice or cider (i.e. to pasteurise it) the product must be raised to a temperature which is generally betwee 55°-65°C.

Nutrients.—Yeast must have a supply of certain essentia materials for its development. These are water, oxygen, carbohydrates, nitrogenous and mineral substances.

Glucose and laevulose are directly assimilable by the yeast. but sucrose must first be broken down into invert sugar by a specific enzyme, sucrase, secreted by the yeast cell itself.

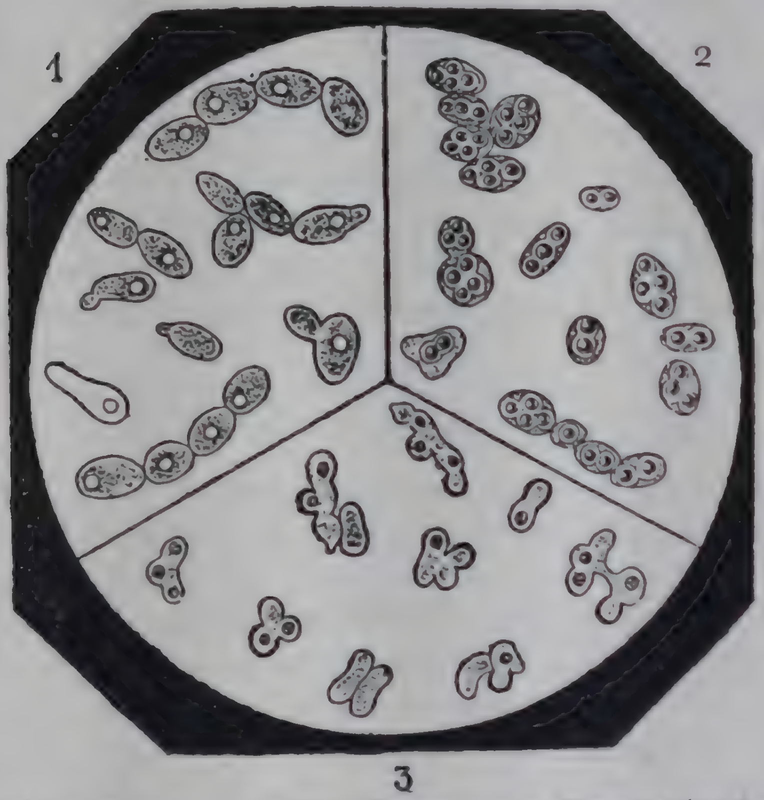
The inversion of sucrose is shown by the following equation:

$$\underset{\text{sucrose}}{C_{12}H_{22}O_{11}} + \underset{\text{water}}{H_2O} = \underset{\text{glucose}}{C_6H_{12}O_6} + \underset{\text{laevulose}}{C_6H_{12}O_6}$$

Certain types of yeast do not secrete sucrase and cannot, in consequence, accomplish the breakdown of sucrose (cf. *apiculatu yeast*, Fig. XXVIII).

Yeasts have very specific needs for nitrogenous compounds.

can utilise only the simpler forms of these materials. Com- albuminoids are rejected but yeasts can assimilate amides ammoniacal salts; they do not appear to possess the general ver of utilising nitrates. The indispensable mineral require- nts of the yeasts are supplied by potassium, magnesium, sul- ur, phosphorus, calcium and iron. Should any one of these ential elements be lacking, the activity of the cell will deteri- te and eventually the organism may die.



1. Budding Yeast 2. Yeast Spores 3. Germinating Spores

Fig. XXVIII. Apiculatus Yeast

Air.—Air plays a most important rôle in the development of asts and the fermentation processes which are consequent pon yeast action.

Aerobic conditions of growth, i.e. in the presence of air, lead a very considerable increase in the weight of the yeast; it evelops at the expense of the sugar in the medium, but very tle alcohol is produced. On the other hand, in anaerobic con- tions, i.e. absence of air, the yeast does not greatly increase in eight, but all the sugar destroyed by the yeast will be con- erted into alcohol.

Natural Acidity of the Juice.—It does not appear that an acid medium is necessary for yeast development. The organisms can accommodate themselves as easily in a juice with 0·1% acidity as in a juice with 0·5% acidity. It must be emphasised that its natural acidity protects the juice against the development of other organisms which are more susceptible to acidity than yeasts.

Yeast Inhibitors.—Sulphur dioxide in the free state is a powerful antiseptic against yeasts and in suitable doses it can completely inhibit or even kill the organisms. Yeasts can, however, accustom themselves very readily to increasingly large doses of sulphur dioxide, so that it becomes difficult to state exact figures for the effect of sulphur dioxide on the yeast—the effect varies with the activity of the yeast, its weight, etc.

Tannins can be considered as materials that inhibit yeasts, but cider yeasts, acclimatised during long years to living in juices containing high tannin contents, are little affected in the majority of cases.

Natural Fermentation by Cider Yeasts

The exact study of fermentation in apple juice is necessarily a matter for microscopic examination. It is seen that the juice contains very large numbers of yeast cells of varying forms, and with quite different characteristics. The natural yeasts are also accompanied by moulds, cocci and bacteria. All these organisms can influence the fermentation process, either in a good or bad sense, and it is of the greatest possible importance that scientific knowledge should be gained regarding their behaviour so that it can be applied to the practical problems of bulk fermentation in the factory.

In 1889, Kayser isolated eleven yeasts from ciders of the highest quality that had been exhibited at the French National Exhibition of Ciders and Perries. Top and bottom fermenting yeasts were noted, and, in each of these two classes, Kayser found types with and without the enzyme which inverted cane sugar. Each yeast exerted its own specific influence on apple juice; some yeasts carried the fermentation process to completion with the production of a dry cider; others were unable completely to destroy the sugar and the cider produced by their use naturally remained sweet.

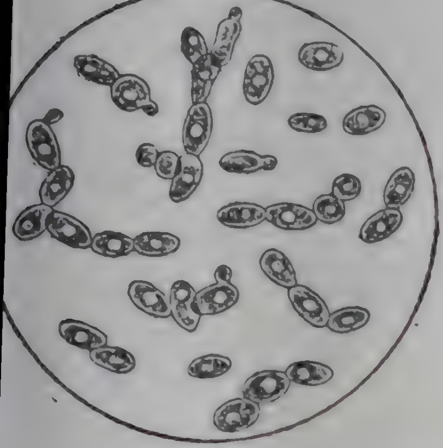


FIG. XXIX.
accharomyces Mali (Duclaux)

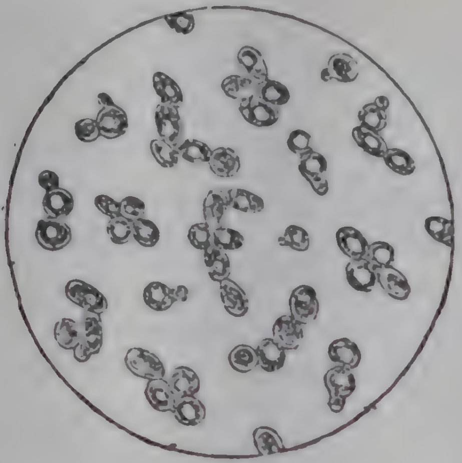


FIG. XXX.
Saccharomyces Mali (Risler)

A short outline of the various yeasts isolated by Kayser is iven here. The data are taken from this worker's *Agricultural Aicrobiology*.

Yeast (*a*).—Top yeast; 6-12μ long; 4-8μ wide; forms a light oating deposit and a film on the surface of the cider after a few ays of fermentation; develops only with difficulty in a 2% artaric acid solution; the products of fermentation are notable or their body and aroma; this sweet cider yeast is *Saccharomyces nali Duclauxi* (Fig. XXIX).

Yeast (*b*).—Bottom yeast; almost spherical cells with diameter -6μ; develops very slowly in 2% tartaric acid solution; the eposit adheres firmly to the walls of the petri dish and does not orm a film; provides a cider with a well rounded flavour; this lry cider yeast has been named by Warcollier *Saccharomyces mali Risleri* (Fig. XXX).

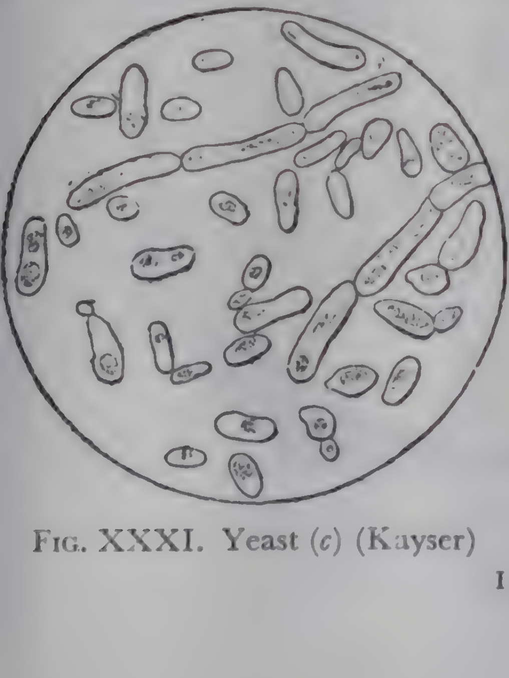


FIG. XXXI. Yeast (*c*) (Kayser)

Yeast (*c*).—Top yeast; elongated, with prominent vacuoles; 4-6μ wide and 6-16μ long; ciders characterised by a unique flavour (Fig. XXXI).

Yeast (*f*).—Possibly a bottom yeast with slightly elliptical cells; 4-6μ long, 4-9μ wide; ferments well in more acid juices (Fig. XXXII—overleaf).

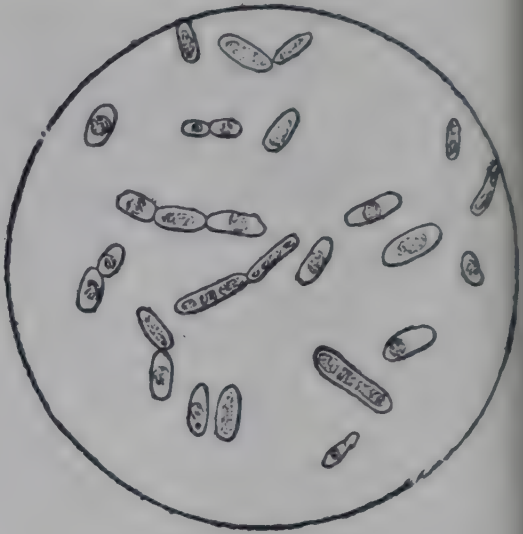


Fig. XXXII.
Yeast (*f*) (Kayser)

Yeast (*l*). — *Saccharomyces apiculatus* (Fig. XXXIII) or at least one of the species which can be so classified; very widespread throughout all fruit areas and identifiable by its lemon shape. This yeast does not sporulate; it can utilise invert sugar but is powerless to ferment sucrose, hence its usefulness in providing sweet ciders.

In 1896, Dienert examined a range of ciders less than one month old, and described nine yeasts, giving their special properties. Dienert stated that those yeasts that left most sugar unfermented in the juice were always those that commenced to ferment at the quickest rate.

These original investigations inspired other workers to extend the microscopic and chemical examinations with a view to their

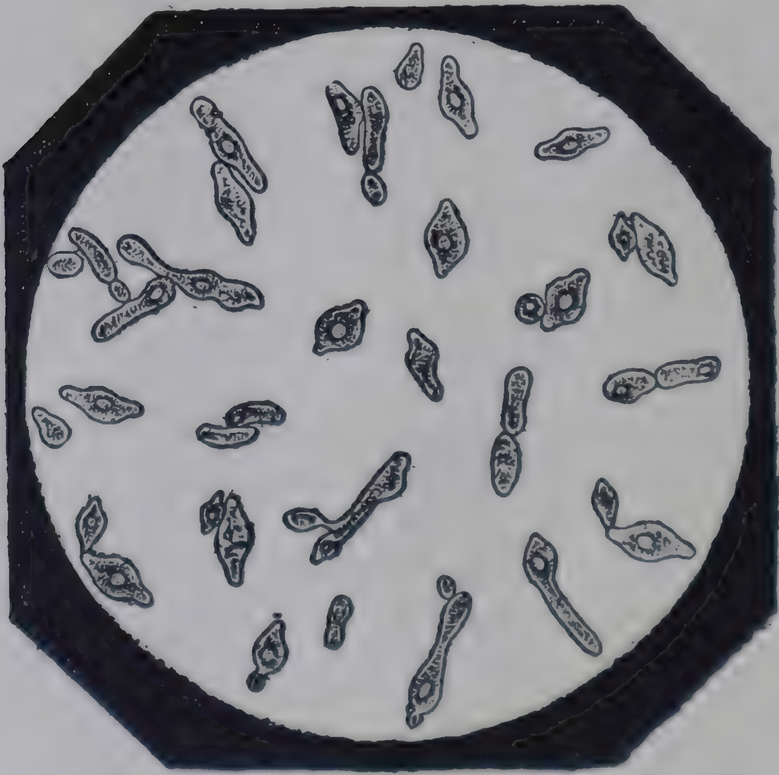


Fig. XXXIII. Saccharomyces Apiculatus

plication to commercial practice. In 1890, Kayser produced eries of ciders from the juice of carefully washed apples. The ce had been inoculated with various yeast cultures, either gly or in different combinations. From the same cider he tained some excellent beverages and some flat products en- ely lacking in character, and concluded that academic re- rch had exhausted its usefulness and that the next forward p must be to examine the problems of pure yeast fermentation the factory itself.

Pure Yeast Cultures

The problems with which the Continental workers were faced volved the production of pure cultures of yeasts and their ansportation to the cider factory to produce ciders with quali- es which could be forecast and which would be superior to ders made by ordinary methods. Many scientists entered this ld of research, amongst whom the following should be men- oned: Kayser, Martinant, Nathan, Müller-Thurgau, Wort- ann, Roques, Alliot, Jacquemin, Dienert, Rosenstiehl, War- llier.

The cider industry, however, would not wait for the results the scientific investigations. Many wild claims were made garding the importance of pure yeast fermentation and some der-makers even believed that by employing such pure cul- res they could obtain high quality ciders from any juice, no atter what intrinsic value it possessed. The results of the ex- erimental work clearly showed that this was a mistaken view nd that the whole question was much more complicated than as supposed to be the case.

When a fresh juice is inoculated with a pure culture of a given east, there will be a mixture of the pure organisms with those aturally occurring in the juice itself. These naturally occurring pes are acclimatised to the juice and can generally develop at more rapid rate than the inoculating organisms and may, in ct, entirely overcome them. Now, it is essential that the domi- ant fermentation should be associated with the pure culture, nd to ensure this dominance, the culture would have to be dded in very large quantities. This procedure, however, im- ediately renders the juice liable to a quick fermentation which undesirable. The ideal method would be to sterilise the fresh juice prior to the addition of the pure culture. Pasteurisation at 60-65°C. will, indeed, produce a sterile juice, but in the processing, the juice acquires a disagreeable cooked taste which, whilst it does largely disappear during the fermentation, can often nullify all the good effects of the dominant fermentation by the special yeast. One further disadvantage of pasteurisation is to be found in the fact that the heat treatment sometimes adversely affects both the ultimate clarification and the normal fermentation of juices, because of the removal by precipitation of a proportion of the assimilable nitrogen compounds of the juice.

An appreciable number of cider-making technicians consider it desirable to carry out a rapid fermentation of apple juice if quality products are required. In thinking along these lines, they are influenced by wine-making technique and they have instituted certain rules of procedure which are very similar to those adopted by the wine industry. For example, this school of thought has recommended that the fermentation of apple juice should be effected at 15-20°C., that the juice should be well aerated, and that the first racking should be accomplished when the peak rate of fermentation has passed and when the gravity of the juice has been reduced to half its initial value.

Warcollier, however, considers that this method only provides uncertain results when applied in the French cider industry in general, although satisfactory products can thus be produced from sharp apples. In Germany, the quick fermentation method is normally employed for the production of completely dry ciders, possessing a vinous character and resembling white wines.

Numerous trials have been made in France to determine whether the process can be satisfactorily applied to juices from bittersweet ciders. The apples were very thoroughly washed, inoculated with vigorously growing pure yeast cultures, and the fermentations were conducted at 15°C. The results were never satisfactory and the process has fallen into disuse.

The most attractive results can be obtained from pure yeast fermentation if the juices to be inoculated are first subjected to the microbiological purification already discussed under the title of 'Spontaneous Clarification (Keeving)'. The significance of this procedure will be dealt with in detail later on.

t is necessary here, however, to refer to several other features
nterest in this subject. Pure yeast fermentation cannot pro-
e a standard quality cider year after year unless the juices
identical in composition and the conditions of fermentation
similar in all respects. It must be obvious that even if the
gar and acid contents of fresh juices can be adjusted to the
me figures year after year, there are other important constitu-
ts that cannot be estimated and which therefore cannot pos-
ly be increased or decreased at will. Nor can the cider-maker
adily achieve or maintain standard conditions for the fermen-
tion processes. Should pasteurisation be favoured, it is not
own whether any positive or regular qualities of the ciders
e due to the yeast or to the effect of the heat, or to interaction
tween the two.

The pure cultures that are generally sent out to factories in
ance are almost entirely strong fermenters, causing a rapid
moval of sugar, and thus completely negativing one of the
rdinal principles of cider-making, namely, the maintenance
a slow, continuous fermentation. The quick fermentation
te lessens the chance of a useful racking and does not conduce
the production of clear ciders of good keeping qualities.

It is quite true that by using pure yeasts, certain ciders ac-
uired a unique bouquet of a very desirable nature, a bouquet
at was not afforded by fermentation with natural yeasts. But
ch ameliorative results were always achieved by the use, not
a single type of yeast, but of a mixture of organisms. The
roblem is complicated by the knowledge that the same mixture
f yeasts will not give identical results with different juices.
ach juice is thus seen to need special investigation and indi-
idual treatment if the best results are to be obtained. Even this
eatment cannot entirely stabilise the quality of the cider from
ear to year, as yeasts that afford excellent results one year will
rnish only mediocre products the next. As Duclaux observed,
t is extremely difficult to arrange successful “ happy marr-
ages ” by using various types of yeasts’.

Commercial cider factories, therefore, cannot expect to obtain
onstant results for the improvement of aroma and bouquet by
he use of pure yeasts for the fermentation of juices from apples
f unknown characters and varieties.

It might be expected that pure yeasts isolated from a high class cider would be capable of transmitting the specific aroma of the parent cider to suitably chosen juices into which they are introduced. In 1928, it seemed certain that the power of transmitting these organoleptic characters from one cider to another was lost by the yeast after several sub-culturings, and that the yeast, after being continually cultured in the laboratory, did not recover this particular capacity. In this connexion, it must not be overlooked that the cider bouquets that are directly due to yeast action are very fugitive and that with the successive rackings and the increasing age of the ciders, they develop and alter in character or even disappear.

It must not be forgotten that some, at least, of the aroma of a cider is due to the flavour of the apples themselves. Warcollier considers it more important to search for a yeast that will accommodate itself to the natural aroma, smell and organoleptic characters of a cider than to seek to find an organism that will make its own individual contribution to the general bouquet of the final product. It is generally found that pure yeast cultures have a destructive effect on the natural flavourings of the apple juice.

There have been attempts to use pure wine yeasts in association with cider. This procedure cannot be entirely rejected; but in France the apple wines so produced would have little chance of consumer acceptance, competing as they would do with sparkling white wines which are much preferred and which cost only slightly more than the apple products.

Experiments with Pure Yeasts

The Pomological Station at Caen, under the direction of Professor Warcollier, has carried out many experiments since 1905 on the general subject of pure yeast inoculations. Yeasts have been isolated from highest quality ciders and from fruits of well-known varieties. It was eventually elucidated that there were no specific yeasts for any single variety of apple, but that some yeasts were confined to special areas. Warcollier considers these to be special Normandy yeasts and Brittany yeasts. On the other hand, one cannot say that there are yeasts special to such varieties as *Bedan*, *Fréquin*, etc. The region in which each yeast originates has a much greater influence than the variety of fruit from which the yeast is isolated.

iice from the *Bedan* variety of cider apple inoculated respec- ly with yeasts isolated from *Domaines*, *Ganevin*, *Joly-Rouge*, *-Bois*, and other varieties, gives ciders similar to those ob- ed from *Bedan* juice fermented with yeasts isolated from *an* apples. Some of the series appear to develop more aroma n the control; in others, the reverse is the case; in no sample, vever, çan any special flavour be detected which is specifi- ly due to the yeast.

gain, juices from *Bedan*, *Domaine*, *Gros-Bois and Marin-Onfroy* e been inoculated with a yeast isolated from the *Joly-Rouge* iety. The resulting ciders showed no similarities to each er. They developed no bouquet in the least reminiscent of *y-Rouge* cider, but each cider showed, to a greater or lesser ree, the same features as control ciders made from the ious varieties but fermented each with its own natural st.

t would appear that the nature of the bouquet of a cider is endent on the variety or varieties of fruit used, whilst the ensity of the bouquet is a function of the yeast. Warcollier's ervations lend weight to the assertion of Jacquemin that the ours due to yeasts are contributed by special etheric sub- nces associated with the changes in composition of certain sses of compounds, such as glucosides of uncertain structure, the juice. It becomes important, therefore, to discover for h juice the yeast which develops in it the maximum aroma. h a problem is extremely difficult to solve.

n view of the much greater demand for sweet cider, it is essary to choose both a yeast and those conditions that will w the fermentation to proceed slowly and to achieve only a tial destruction of sugar.

n the first place, the use of certain yeasts which do not secrete rase, and which cannot therefore ferment cane sugar, has n considered. This involves both the removal from the juice ll organisms capable of fermenting sucrose, and a laboratory mination of yeasts which do not secrete sucrase, as amongst ir number can be found some that ferment only weakly, ilst others contribute a disagreeable aroma to the cider.

t is by no means certain that, given a sterile juice which has suffered excessively in the pasteurisation, and an effective st which does not secrete sucrase, the final product will be satisfactory. It has been shown that by varying the nutrier supplied to some of this type of yeast, one can modify the cha acter of the yeast to such an extent that it develops the pow of fermenting sucrose.

Kayser has shown that some sucrose-destroying yeasts, eith singly or in combination, do not completely ferment the cid and he concludes that he had isolated sweet cider yeasts. Alli has isolated a yeast of very feeble fermenting power from t sugar cane. Gimel and Pique recommend the use of a yea *Pseudo-Saccharomyces apiculatus asporogenes.*

More recent research work has suggested that the yeas power of attenuation, i.e. its ability to take the fermentation the sugars to completion—is correlated very largely with t mineral and nitrogen content of the juice.

Warcollier has isolated from ciders remaining naturally swe a series of yeasts which he has called 'sweet cider yeasts'. Inoc lated into some juices, these yeasts have provided sweet cide but whenever they are added to certain other juices that pr vide a suitable medium they can carry the fermentation completion and totally destroy the sugar.

The significance of this work is that true, sweet, cider yea which will give reproducible results with all juices have not been isolated.

Further Experiments on Pure Yeasts

In 1894, Lloyd in England studied the effect of various yea from wine and cider (*Kingston Black*, *etc.*) when inoculated i apple juice, and found that the ciders so produced could be c tinguished from each other by their aroma and bouquet. T juice fermented with a wine yeast had acquired a vinous aro (Pasteur noticed the same phenomenon when fermenting b with a wine yeast); similarly, fermentation with *Kingston Bl* yeast produced in different apple juices a series of ciders wh corresponded in character with the true *Kingston Black* produ

In every case, the Somerset apple juice gave superior bev ages (similar to *Kingston Black*) to juices from Devon or He ford, showing that the yeast and composition of the juice pl a rôle in certain circumstances which can become of prim importance.

The effect of pure yeast cultures can be enhanced by wash iit with exceptional care. This washing, however carefully arried out, has variable results. Sulphur dioxide is often to the fresh juices partially to sterilise them, or, more y, to inhibit temporarily the yeasts and other organisms juice, and to encourage the ultimate development of the yeast. The addition of sulphur dioxide to a fresh juice s in part of the sulphur dioxide becoming combined, the emaining free, this being the only fraction which possesses eptic properties. The ultimate action of sulphur dioxide epend on the quantity of free sulphur dioxide in the juice, his, in turn, will be correlated with the nature and comon of the juice (i.e. its aldehyde and oxidase content).

ose bacteria that are responsible for disorders in cider are sensitive to sulphur dioxide than the yeasts, so that the ur dioxide treatment can aid the achievement of a pure entation. When sulphur dioxide is used during the keeving ess, the racked juice will be particularly suitable for pure fermentation at a low temperature.

e treatment of a juice by heating prior to inoculation with re yeast culture does not always give good results. Kayser, a Kuhn pasteuriser at 70°-77°-82°C., found that the juices acquired noticeably cooked tastes. Lower temperatures ld be used both to avoid this taste and also to prevent loss rogenous substances by precipitation. Warcollier has estabd that a single heat treatment at 65°C. or two treatments °C. is sufficient for the purpose and rarely gives a cooked to the cider.

Bouquet due to Yeasts

e complete bouquet of cider is partly due to the fruit itself partly to an aroma produced by the yeast fermentation, attempts have been made to influence the latter by effecting ations in the composition of the juice and, in consequence, e aromatic substances developed by the yeast.

e main worker in this field was Kayser and some data of his ented to the National Congress in 1921 are reproduced here. Ve have sought to interpret the influence of nitrogen on na. The importance of nitrogen can be demonstrated by nple experiment. An apple juice is generally rather low in gen if it has been pasteurised; one fraction of the nitrogen has been precipitated, and thus has become incapable of assimilation by the yeasts, and certain species of yeasts will refuse to develop in such a medium.

Experiment 1.—An apple juice which had been previously sterilised, filtered and re-sterilised was inoculated with various cider yeasts; one set of flasks received no additions (control); the others were treated with 0·1 % nitrogen in the form of ammonium sulphate or asparagine. The following table shows the results obtained. The fixed ethers are expressed as ethyl malate, the volatile ethers as ethyl acetate and the volatile acids as acetic acid.

(*a*) *Controls. No Addition*

Yeast	*152*	*153*	*157*	*158*	*153 + 158*
Alcohol (% wt.)	1·43	1·91	1·75	1·43	1·91
Volatile acidity (% acetic acid by wt.)	0·0891	0·0433	0·0335	0·0502	0·0526
Fixed ethers (% wt.)	0·2352	0·2637	0·2502	0·2239	0·1742
Volatile ethers (% wt.)	0·0114	0·0060	0·0101	0·0312	0·0143

(*b*) *Ammonium Sulphate added*

Alcohol (% wt.)	1·67	3·12	3·28	1·67	3·12
Volatile acidity (% acetic acid by wt.)	0·1005	0·0216	0·0415	0·1448	0·0216
Fixed ethers (% wt.)	0·1734	0·2173	0·1564	0·1696	0·1696
Volatile ethers (% wt.)	0·0202	0·0053	0·0105	0·0170	0·0106

(*c*) *Asparagine added*

Alcohol (% wt.)	2·15	3·00	3·00	1·43	2·96
Volatile acidity (% acetic acid by wt.)	0·1099	0·0351	0·0469	0·1274	0·0433
Fixed ethers (% wt.)	0·2464	0·2133	0·3083	0·1945	0·1823
Volatile ethers (% wt.)	0·0123	0·0045	0·0114	0·0173	0·0121

It is seen that different yeasts are not all equally sensitive to the lack of nitrogen. Increasing this element may produce more alcohol and there has been an increase in volatile acidity in the experiments with all yeasts except No. 153. The formation of ethers is also very variable according to the yeast and according to the exact form in which the nitrogen is added. In the experi-

s tabulated above, two yeasts, Nos. 152 and 158, were of
piculatus type and were clearly distinguished from the vig-
s yeasts Nos. 153 and 157.

xperiment 2.—A further trial was made with an apple juice
higher sugar content treated with equivalent amounts of
ıonium sulphate and ammonium phosphate and then in-
ated with yeasts Nos. 153 and 153 + 158 (*apiculatus* type).

	Control	*Yeast* 153		*Control*	*Yeast* 153+158	
		Ammonium sulphate	*Ammonium phosphate*		*Ammonium sulphate*	*Ammonium phosphate*
ıol -	2·15	5·29	5·05	2·51	5·53	5·53
tile acidity cetic acid vt.)	0·0206	0·0394	0·0464	0·0495	0·0610	0·0552
l ethers wt.)	0·2949	0·2377	0·3654	0·2163	0·2252	0·3042
tile ethers wt.)	0·0103	0·0120	0·0173	0·0194	0·0169	0·0190

itrogen in the form of ammonium phosphate produces more
eric compounds than in the form of ammonium sulphate.
ere is little significant difference between the yeast activity
Io. 153 alone or in combination with an *apiculate* type.

xperiment 3.—Ammonium sulphate, ammonium phosphate
ısparagine, were added to grape juice, the additional nitro-
being 0·1 %. The juice was sterilised and inoculated with
e yeasts Nos. 32, 42 and 101.

ome of the results are given here:

ast	*(results as % by wt.)*	*Control*	*Ammonium sulphate*	*Ammonium phosphate*	*Asparagine*
2	Fixed ethers	0·188	0·201	0·378	0·243
	Volatile ethers	0·0095	0·0098	0·0108	0·0101
	Volatile acidity	0·0552	0·0331	0·0663	0·0663
2	Fixed ethers	0·212	0·198	0·288	0·273
	Volatile ethers	0·0164	0·0193	0·0416	0·0313
	Volatile acidity	0·076	0·0578	0·0641	0·0820
1	Fixed ethers	0·137	0·283	0·393	0·307
	Volatile ethers	0·0080	0·0094	0·0109	0·0112
	Volatile acidity	0·0152	0·0271	0·0271	0·0552

The table indicates that yeast No. 42 (*Sauterne*) has had a
ent effect on the production of ethers.'

Müller-Thurgau and Osterwalder have also shown the im-
rtance of nitrogen on the fermentation of apple and pear
ces. These workers studied the problem from a different point

of view, namely the influence on fermentation of additions o nitrogen to juices expressed from fruit at various stages of ripening. Thus, they first fermented juices from very under-ripe pears; then other juices from the same sort of pears which had become just ripe were fermented, and lastly, juices from the same fruit left until it was quite over-ripe were similarly treated In each case they added 0·4% nitrogen (ammonium phosphat and ammonium chloride) to one set of samples, and the experiment was completed by the inclusion of a further set of sample for inoculation with pure yeasts. Four varieties of pears wer used and the juice was pressed from the pears at various stage of maturity. One variety was extremely rich in tannin; anothe was a late variety with a high acidity.

The Swiss workers showed that the juice from under-ripe pears contained more assimilable nitrogen than the juice from ripe or over-ripe fruit, although it was comparatively poorly supplied with active yeasts so that the fermentation was slow and difficult.

The addition of active yeasts to the juice from under-rip pears produced the same effect as the addition of nitrogen to the juice from ripe fruit. This yeast addition also had the effec of producing a more vigorous fermentation, and of inhibitin the development of *apiculate* types of yeasts which are more prevalent on under-ripe than on ripe fruit. Thus, the addition o a yeast culture is to be recommended in cases similar to thi experiment. It was also noted that the addition of nitrogen ca have a considerable influence on the production of ethers according to the yeast employed.

The usual acidity of apple juice favours the normal alcohol-producing yeasts at the expense of other organisms that seek t share the nutrients of a juice. An acidity of 0·2-0·4% is sufficien for this purpose. In some juices the acidity is very low, an some yeasts are extremely susceptible to different acidities There seems to be a certain optimum ratio for acidity/sugar t obtain the best results.

An experimental juice was prepared and divided into separate aliquots with acidities ranging from 0·4-0·7%. The aliquot were inoculated with two wine yeasts. It was noted that the tw yeasts were capable of fermenting sugars to varying extent their capacity depending on the individual yeast and the acidit e medium. Further, the amount of unfermented sugar in edium with 0·4% acidity and 13% of sugar was greater than medium with 0·7% acidity and 14% sugar, indicating that acidity of the juice does exert an influence on the course of entation.

Influence of Acidity on Fermentation

	Initial	*Yeast No. 14*		*Yeast No. 37*	
Tartaric acid %	*Sugar Content* %	*Residual Sugar* %	*Volatile Acidity* %	*Residual Sugar* %	*Volatile Acidity* %
0·4	13·0	1·090	0·025	1·200	0·025
0·4	16·0	0·374	0·034	0·605	0·033
0·6	11·0	Traces	0·034	0·344	0·031
0·6	14·0	0·722	0·044	0·672	0·038
0·6	18·0	2·664	0·073	1·903	0·044
0·7	14·0	Traces	0·043	0·355	0·036

Malic acid is more acceptable for fermentation than citric or taric acids. Its physiological effect is not correlated with the centration of the acid; the effect of an acidity of 0·67% is greater than an acidity of one quarter of this amount; with hly acid media, less volatile acids are formed, with a simul- eous production of greater quantities of etheric substances.

Use of Pure Yeast Cultures at 15°-18°C.

Although vigorous yeast cultures cannot be used in a general y with sweet juices, there are certain conditions in which ch pure yeasts have a positive rôle to play. Pure yeast fermen- ion is recommended for rapid production of ciders to be arketed in September and October; for ciders to be distilled potable or industrial spirits; and for the production of spark- g ciders by the method employed in the wine industry, de- ned to compete in other markets with German cider products. the last case, wine yeasts should be chosen, as the German oducts are produced by fermentation with such yeasts. Again, is better to use pure cultures of yeasts for the fermentation of ices from apples harvested in poor or wet conditions, or for y juices which are already seriously affected by wild organ- ns. More regular fermentations and better keeping qualities the ciders are thus assured.

Finally, pure cultures of yeasts should be employed in dis- icts isolated from the main cider areas, for in these places the apples will be associated with wild yeasts which are responsible for irregular fermentations.

Yeast Starters

(*a*) Clean, well washed apples should be taken and milled in a carefully cleaned mill. 4 gallons of juice are heated to 60-65°C. and cooled in a clean, covered vessel until the temperature falls to 25°C. The contents of the flask of pure yeast are then added to the juice. Fermentation will commence in a few hours, and when maximum activity has been reached, i.e. in 1 or 2 days, 20 gallons of juice, prepared and pasteurised as indicated above are added to the fermenting liquor. The resulting 24 gallons when in full fermentation, are sufficient to inoculate about 20 gallons of juice. The starter should always be prepared in such a volume as represents one tenth or one twentieth of the volume of juice to be fermented.

(*b*) The cider-maker who uses his own apples can make a starter by utilising the yeasts on his fruit. The finest, cleanest and ripest specimens should be chosen and milled in a very clean mill. 4-6 gallons of juice should be heated to 25°C., 1/6th of an ounce of ammonium phosphate added, and the juice covered over with a clean cloth. Fermentation can be hastened by occasional stirring of the juice, but usually 2-3 days are needed and when maximum activity has been attained, the fermenting liquor can be used to inoculate 20 gallons of juice sterilised by heating. This starter, when fully active, can be used as in (*a*) above.

Use of Pure Yeast Cultures at Low Temperatures

The employment of pure yeasts is particularly satisfactory fo cider-making when low temperatures are available. The starte should be added to a juice which has been correctly keeved and cooled to 5-6°C. The pure yeasts, acclimatised to low tem peratures, develop more rapidly than the natural yeasts of th juice and thus give the effects desired from a dominant, pur yeast fermentation. Such fermentations are akin to 'botton fermentation' technique in brewing.

The cider-making industry will never achieve a standardised controlled production until it has installed the necessary refri

ting machinery to enable all fermentation processes to be
ed out at low temperatures.

Rôle of TORULA *in Cider-Making*

orula yeasts are widely distributed in the soil, under fruit
, and on their bark and leaves. They reproduce themselves
udding; they are oval in shape, exist in a variety of forms
do not produce spores. They are often red in colour. Kayser
conducted an intimate study of these organisms (*Comptes*
dus Académie d'Agriculture, 8th April 1925). They are capable
ermenting glucose and sucrose and, in some cases, maltose
ilar to certain *Sauterne* yeasts). They are distinguished by
latively high production of ethers and by their high power
xidation.

ayser showed that the *torula* which he investigated preferred
de to ammoniacal nitrogen. The production of ethers is
endent on the nitrogen content. *Torula* are aerophilic and
duce greater amounts of ethers at the surface than in the
th of the liquor. These yeasts can release aromatic com-
nds from the skin of the apples more readily than ordinary
sts.

t is very probable that cider produced by means of *torula*
roves in quality when bottled, by virtue of the enhanced
er content.

here have been indications that fermentation with pure cul-
es of torula can afford interesting results so far as bouquets
aroma are concerned, but until the practical technique of
e yeast fermentation has been placed on a satisfactory basis,
use of *torula* will probably not develop to any great extent.

TRANSLATOR'S ADDENDA

Pure Yeast Cultures

s an example of the modern use of pure yeasts for cider-
king, the following notes obtained in 1938 from the Geisen-
m Research Station in Germany illustrate the procedure
t was being adopted there. Many thousands of these pure
tures were despatched to cider-makers each year during the
king season. As the preparation of such cultures and their
culation into juices is of interest only to those with technical

qualifications, the German data have been given in the origina metric system. The yeasts that proved most satisfactory for cide were *Steinberg*, *Waldenberg* and *Reisling*.

The pure yeast cultures of the Geisenheim Station are sen out in sparkling wine (Champagne) bottles, which may be opened only immediately before use. If the utilisation of th yeast is not possible at once, then the bottles should be store in a cool, dry room. Since the activity of the yeast is preserved b this means, the inoculation of the yeast can be undertaken whenever appropriate, but in any case not later than 14 days.

A culture suffices for the inoculation of 50-70 litres of juice If larger quantities of juice are to be brought into fermentation then a yeast inoculum must be prepared first. For this purpose well cleared juice from completely sound ripe apples is use and is pressed 8 days before the main vintage. This initial juic is heated to boiling in an enamel or earthenware jar and the placed in a carefully cleaned fermentation flask or a small vesse rinsed out with hot but not sulphited water, preferably whil the liquid is still warm. This vessel is carefully closed with fermentation lock and allowed to stand until the contents hav cooled to room temperature, i.e. to about 18°C., when the liqui yeast culture is poured into the juice after which the fermentation lock is immediately replaced.

Since a strong CO_2 pressure often forms in the culture bottl on account of which the yeast is forced out on opening th bottles, the stopper is first bored through with a corkscre before loosening the wire fastener, and the CO_2 allowed t escape. Only then is the wire loop removed and the stoppe carefully drawn. The yeast is now poured at once into the juic the empty flask rinsed once with some juice, and the fermentation vessel closed with a fermentation lock. The juice the stands at 15°-18°C. until it ferments. After 5-6 days it is suitab for inoculation purposes. 10 litres of juice are mixed with th yeast culture, providing a strongly fermenting inoculum whic suffices for the fermentation of 2,000-2,400 litres of juice.

When the yeast inoculum (i.e. the initial preparation wit the juice) has come to active fermentation, it is added to th main vintage after stirring and shaking up the bottom yeas The amount of the sowing is proportional to the sugar conte of the juices. With low sugar juices, such as apple and pea gravity does not exceed 1·050-1·080, an inoculum of ·3% of yeast preparation is sufficient.

th such juices one should add:

to 500-600	litres of juice		1¼-1¾ litres yeast inoculum		
o 1,000-1,200	,,	,,	2½-3½ ,,	,,	,,
o 2,000-2,400	,,	,,	5 - 7 ,,	,,	,,

the case of juices with higher sugar content, for example e juices and sweetened fruit juices, the size of the sowing creased to 0·5%. Such juices should therefore receive:

to 500-600	litres of juice		2½-3 litres of yeast inoculum		
to 1,000-1,200	,,	,,	5-6 ,,	,,	,,
to 2,000-2,400	,,	,,	10-12 ,,	,,	,,

ith strongly sulphited juices the amount of yeast inoculum ised according to requirement to 1%. In this case, 5-6 litres e yeast preparation should therefore be added to 500-600 s of juice.

he addition of the yeast should follow as soon as possible pressing the juice. The pure yeast can only develop its activity if it is sown out before irregular fermentation mences.

warm vintage weather it is recommended to add the yeast paration to the unpressed pulp. This is especially necessary e pulp is not pressed at once but must remain standing for e time.

he use of pure yeasts requires that a large head space above juice be left free in the fermentation vessel and that fermenon is carried out at a cellar temperature of 15-18°C. At a her temperature, juices treated with pure yeasts ferment ch too rapidly. Since the duration of fermentation is shored by the addition of yeast, and the clarification of the cider elerated, the racking should be undertaken sooner in pure nentation than in natural fermentation.

CHAPTER XI

PRIMARY FERMENTATION

HAVING successfully operated the keeving process and with drawn a clear product from the top and bottom deposits in th keeving vessel, the juice is taken to fermentation vessels place in cellars which should be as cold as possible. The main fermentation process will now commence; it should continue, unde normal conditions, until the sugar has completely disappeare and the cider becomes 'dry'.

Composition of the Juice

Certain observations on the composition of the juice ar necessary before the main fermentation process is considere

(*a*) *Oxygen.*—The juice is naturally poor in oxygen, for thi element cannot long remain in the juice in a dissolved state o account of its continual interaction with tannins and other compounds. The fermentation of the juice should not be expedite by aeration but rather by aerating a small volume of the juic (i.e. a starter) which can then be mixed into the main bulk.

(*b*) *Nitrogen.*—The juice is usually low in nitrogen. Warcollie quotes from his experiments the following figures for variou juices:

Type of Juice		*Total Nitrogen %*
Gros-Bois		0·0044
Cartigny		0·01
Gros-Bois		0·0086
Marin-Onfroy		0·0092
Gagnevin		0·0057
Mettais		0·0032
Bedan (Mosles area)		0·0060
Bedan (Beuvron area)		0·0046
Mixed Varieties	Rumesnil area	0·012
	Beuvron area	0·0080
	d'Auge and Bessin	0·0057
	d'Auge and Bessin	0·0036

On an average the juice contains 0·01 % of total nitrogen, which only one half is assimilable by the yeast; this accoun

ne very slow fermentation of some apple juices and why
ferment much more slowly than wine or beer.

Malic Acid.—Yeasts develop satisfactorily in juices of
um acidity, but excessive acidities tend to inhibit their fer-
ative capacity.

Normandy and Brittany, juices have acidities ranging
een 0·14-0·55% malic acid, and these juices undergo nor-
fermentations. Very high acidities are rarely encountered
ew of the practically complete eradication of sharp varieties
the cider orchards. The lack of acidity is sometimes ap-
nt, for the resulting ciders are flat and are predisposed to
ening and acetification. When such low acidities are en-
tered or expected to arise, 0·05% of tartaric acid (the
imum allowed by French law) are added. Should this
unt not suffice, the varieties of apple used for the blend
t be varied to include more sharp fruit.

is not possible, on *a priori* grounds, to be dogmatic con-
ing the optimum value for acidity to give the best ciders.
ers made from juices with 0·14-0·50% acidity will be similar
ne Normandy products; those made from juices with 0·50-
% acidity will resemble Brittany ciders made from such
eties as *Jaune*, *Cazo*, *Gilet Rouge*, or ciders made from apples
vn in the north and east of France; and finally, ciders made
n juices with 0·82-1·37% acidity will possess similar charac-
to ciders from the Aube region or to German ciders made
n such varieties as *Bohnapfel*, *Champagner Reinette*, *Heider-*
l, etc.

he ideal acidity from the point of view of taste can only be
ermined by tasting, and the cider-maker should consider the
ite of his customers when making up his blends for fermen-
on.

the available blend of apples provides an acidity of more
n 0·55% malic acid, the pectic compounds are precipitated
n the lees and the head is of minor proportion; in these cir-
nstances, the cider can be clarified by repeated rackings.
ese juices are usually resistant to disorders because of their
anced acidity. Such ciders are not generally fit for consump-
during the first year of their life. Two or three years of
turing, however, remove the rough, harsh taste and they
elop excellent characters. (Warcollier: *Fruits used abroad for*

the making of ciders. Utilisation in France of the same varieti Privately published.)

During the fermentation of these acid juices, the malic ac disappears to a large extent, thus improving the flavour by r ducing the sharpness and throwing into relief the residual swee ness. Kulisch has shown that ciders may lose up to 40% of th original acid content during fermentation; Lechartier exten this figure to 65% of the original malic acid. Many scienti workers have examined this phenomenon and it appears certa that the loss is due to bacterial action. Seyfert has isolated fro wine a *Micrococcus malolacticus* which can destroy up to 60 of the malic acid in a medium containing this acid.

In 1913, Müller-Thurgau demonstrated that the loss of ma acid in ciders and perries was accompanied by the formation lactic acid and carbon dioxide. The responsible bacteria most active between 20°-25°C.; during the winter they rem dormant. Reduction of acidity proceeds most rapidly in cid which remain on their lees, and racking will considerably ret the process; a rapid fermentation permits the bacteria to deve at an earlier stage. Tannin retards the effect to some exte whilst sulphur dioxide is a powerful inhibitor of the causal b teria when used at the rate of 0·01-0·02%.

The loss of acidity by bacterial action consequently has ameliorative effect on sharp cider, but, on the contrary, i most undesirable in low acid ciders.

Practice of Fermentation

The fundamental rule for the production of good cider i conduct the fermentation process slowly and at a temperat which should never rise above 5°C. Only by fulfilling this c dition can the best ciders be obtained, with a fine aroma flavour and good keeping properties.

The ideal rate of fermentation is that which leads to a p tically complete cessation of the yeast activity whilst some su is still left in the cider. Such a result is often impossible in po constructed cellars; the fermentation continues slowly but evitably to its conclusion; the cider remains cloudy for a p tracted period on account of the constant evolution of gas, the consequent movement in the cider caused by the ascen bubbles of gas. The eventual complete cessation of the ferm ı process renders the cider liable to acetification, the cider ning hard and eventually undrinkable.

avoid these various mischances, the cider must not only aintained at low temperatures, but care must be taken to ent contact of the yeast with air which will accelerate its ity. Lastly, the ciders should be freed from the organisms ng disorders by one or other of the processes of racking, g or filtration.

Cellars

suitable cellar or fermentation room is absolutely essential orrect fermentation, and yet in the French cider-making stry very little importance has been attached to this prime or and very few really good cellar installations were to be d in 1928. The fermentation room should be capable of g maintained at 5°C. by the use of artificial refrigeration. ller makers, who cannot afford to install such machinery, ıld endeavour to obtain suitable cellars which are naturally . The cellars of Normandy are often imperfect, with walls uently constructed merely of earth.

he prevailing temperature should never rise above 10°C. should be as constant as possible. The hygienic condition ıld be sound and the atmosphere should neither be too ıp nor too dry. Ventilation should be provided in some ple manner so as to avoid the penetration of excessive heat cold. The entrance to the cellar should be protected by a ble door. It is very useful, where possible, to make use of lky hills in which natural cellars can be excavated, as is e in Normandy.

German cellars are very elaborately designed and maintained h great care. In large factories, the cellars are at two levels, first for the fermentation process itself, and the second, at eeper level, for storage (8-10°C.).

Casks

These should be maintained in conditions of scrupulous cleaness. The size should not be too small so that variations in bient temperatures will not affect the temperature of the er to an appreciable degree. Cellars with inferior conditions emperature control should be provided with casks of at least

200 gallons capacity. Power recommends casks rather than va up to 1,000 gallons in capacity, but beyond this, i.e. 2,000-4,00 gallons and above, vats present several advantages over woode vessels, provided that suitable precautions are taken.

Wooden vessels should be protected from the effect of evaporation of the cider through the pores of the wood. The speed c evaporation will vary mainly with the exposed surface of th wood; with two casks of the same shape and thickness, th smaller cask will lose proportionally more liquor through evaporation than the larger cask, because, relative to its volume, i surface is much greater.

For example, a cask of 50 gallons capacity has a surface are of 10 sq. ft., whereas a cask with half that capacity has an are of only 2½ sq. ft.

The use of wooden vessels for fermentation processes in cide factories has been dealt with by Warcollier in a contribution t the 5th Congress of Industrial Chemistry (1925) and is reproduced here in an abridged form.

Wooden Vessels for Fermentation Processes

These vessels are often the source of a variety of unpleasa tastes in cider, which are extremely difficult to remove witho entirely denaturing the product. Generally speaking, these fl vours are due to moulds which develop in the pores of the woo even if no cider is present in the cask, it is possible for extreme unpleasant aromatic substances to be formed in the presence small quantities of water. Reasonable care of the wooden vess in the factory will avoid all these difficulties. Mould develo ment can be prevented by maintaining the casks in a dry co dition by means of a continuous stream of air, or better sti once the cask is dry, a sulphur match should be burnt in every three months.

Once a cider has been attacked by any of the various tai which are due to the condition of the casks, very little can done to improve the quality. Treatment with oil emulsions mustard flour, as for wines, is hardly suitable for ciders, for t violent agitation needed for this method will seriously aff the quality of the cider. Distillation is of little use, since t offending substances in the cider are volatile and distil ov with the apple spirit.

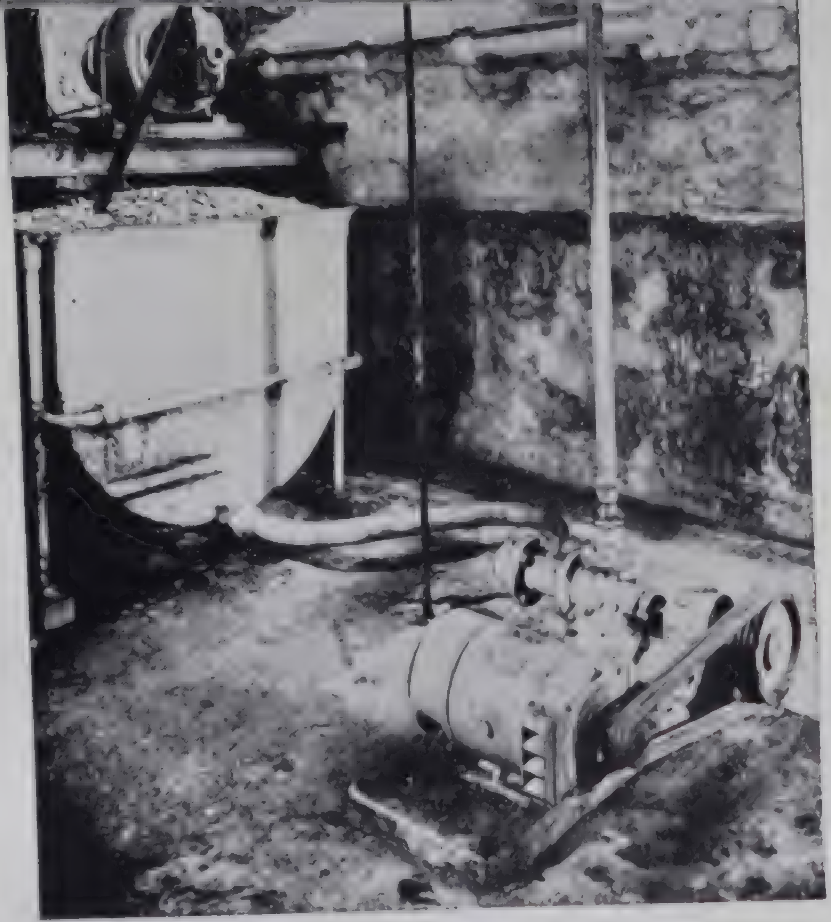


Fig. XXIII. D6 and D3 Mono Pumps operating on milled apple pulp and apple juice respectively

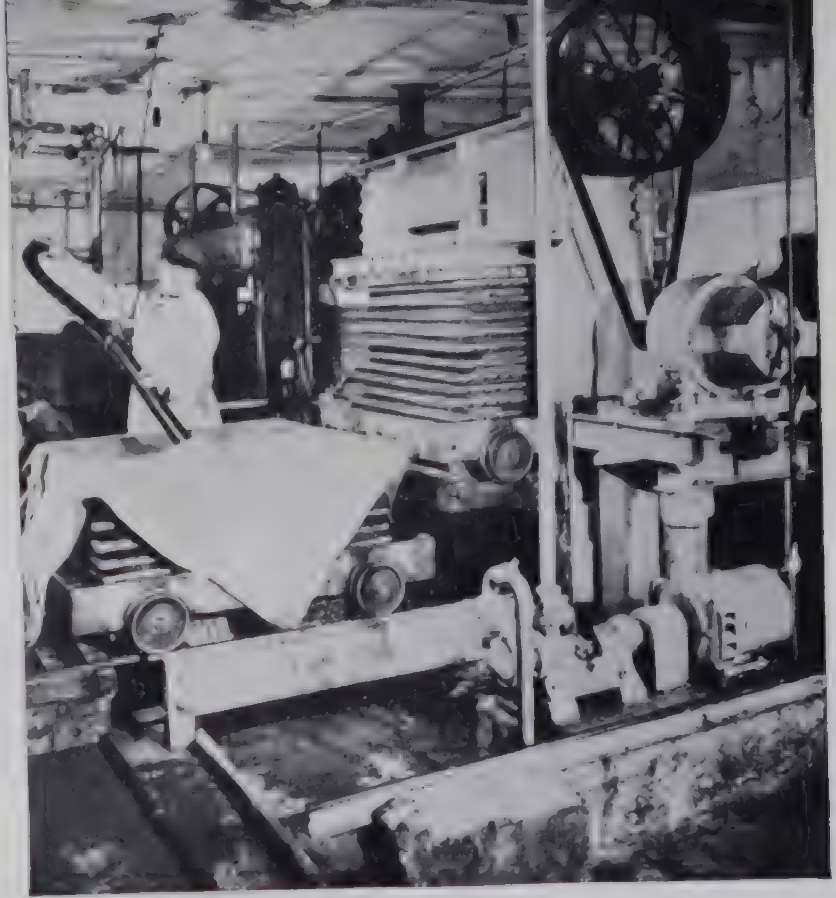


Fig. XXIV. D6 Mono Pump

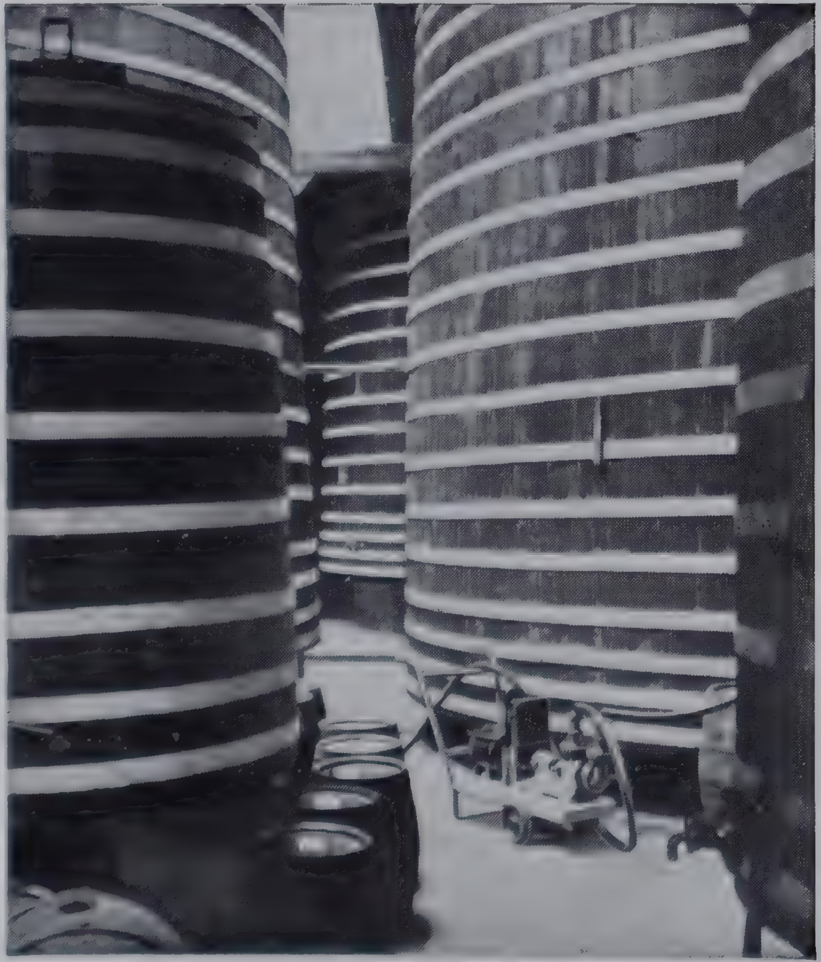


FIG. XXV. D3 Portable Mono Pump (for racking cider)

FIG. XXVI. A.P.V. Stainless Steel Pump for Portable Liquids (external view)

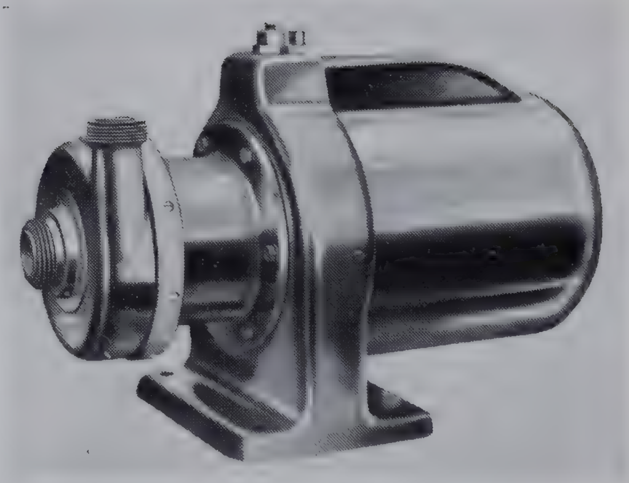
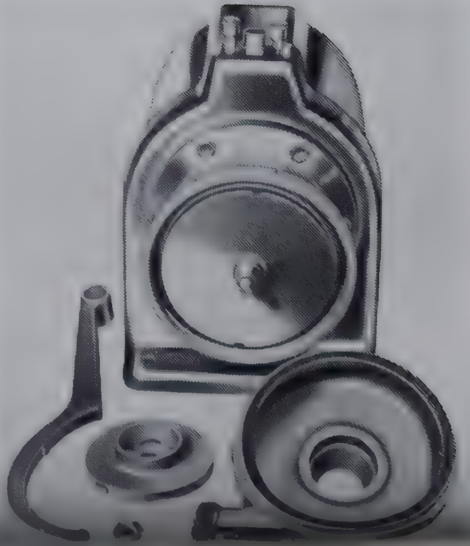


FIG. XXVII. A.P.V. Stainless Steel Pump (dismantled)



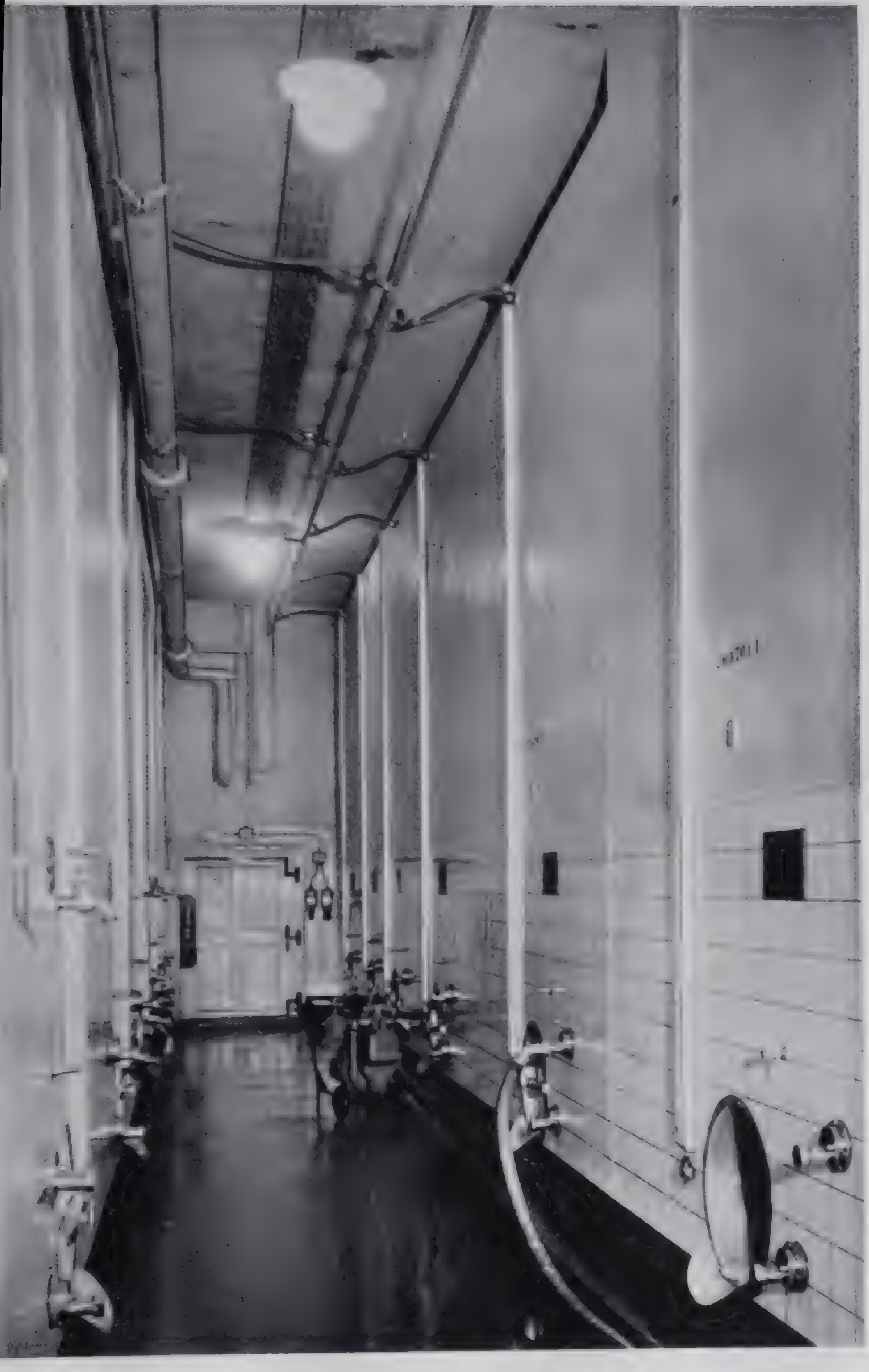


FIG. XXXVI. Swiss 'Ebon' Vats for Cider (external fittings)

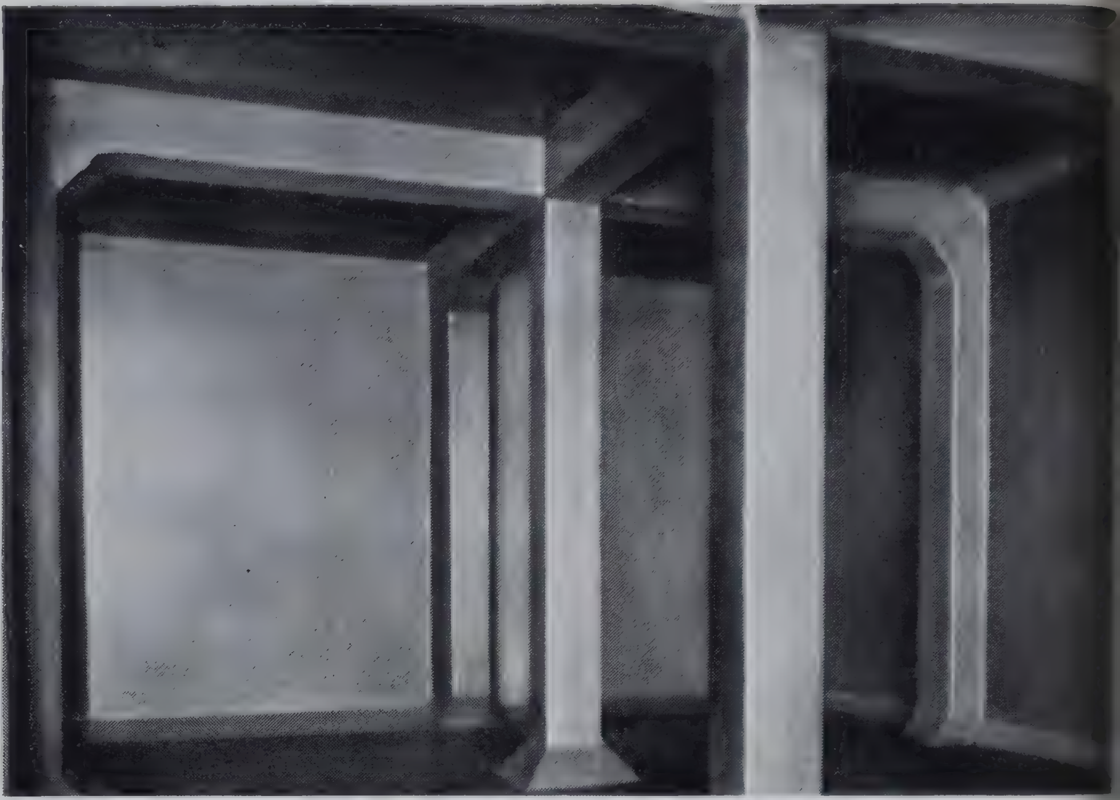


FIG. XXXVII. Ebon Vat for Cider Storage (internal view of 75,000-gallon tan

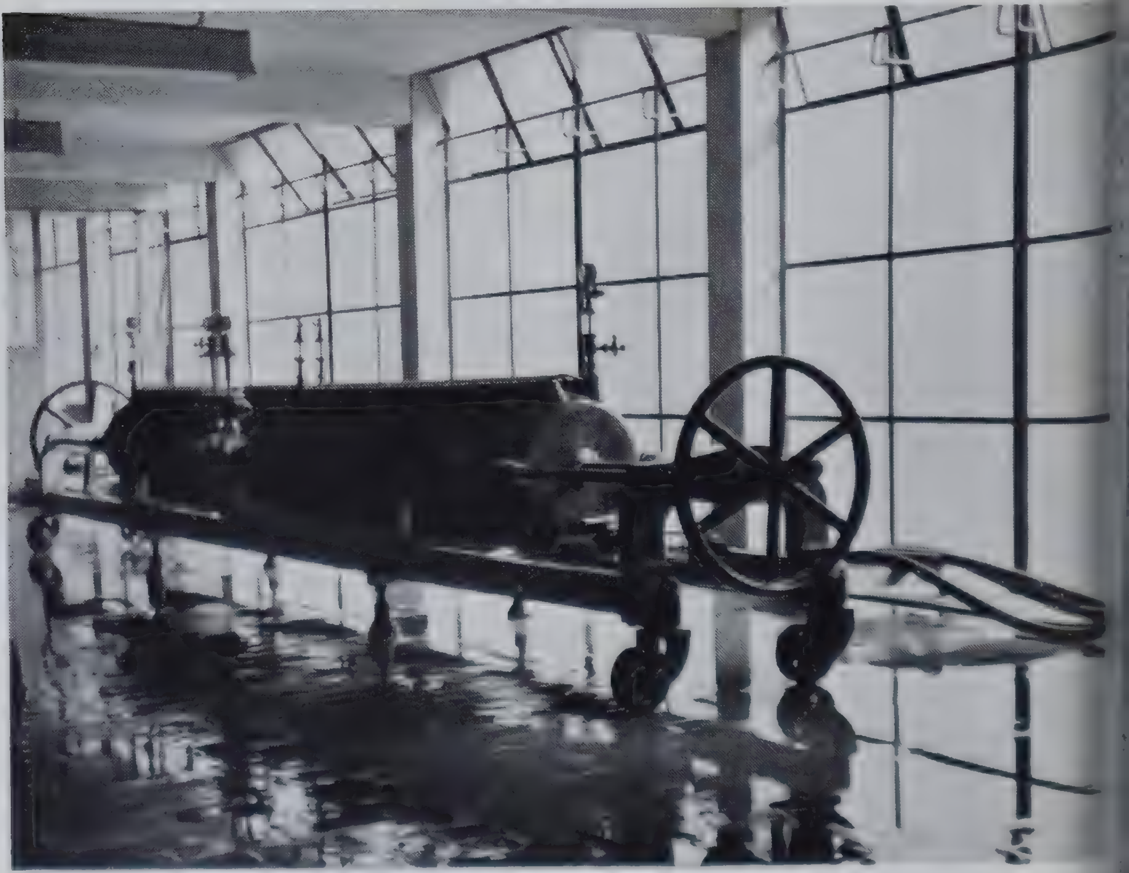


FIG. XL. Adlam Pulp Filter

struction of the flavouring before distillation by such pro-
es as oxidation, reduction or saponification have proved
useless. Warcollier has encountered many cases where
table materials used for lining the casks had contributed
l aroma to the cider. Again, trouble has been caused by
se of red pine wood which was not suitably seasoned and
h contained all its natural aromatic constituents. White
l only should be used.

r the cleanliness of wooden vats during the closed season,
collier recommends painting them with a suspension of
in 90% alcohol or simply with ordinary lime. The liming
be renewed every three to six months if necessary, and it
be easily removed with water when the vats are needed
ervice.

ccidents have been caused by the use of tar in the cider
ory to cover wooden or metallic apparatus. The removal of
aste of tar from the ciders proved to be impossible.

Ullage

asks which are in use should constantly be filled up to re-
e liquor lost by evaporation. This operation should be per-
ned, when possible, by filling the cask from the same batch
roduct. In some cases, however, filling with cider is not ad-
ble as the mere action of pouring in fresh liquor disturbs the
r already in the cask. In such cases, the air space in the
el should be filled with carbon dioxide. In large installations
rmanent carbon dioxide supply is led to each vessel so that
process can be very simply accomplished. The carbon di-
le needed for this purpose can be collected from vats where
es are undergoing the fermentation process; the gas is com-
sed and used from some suitably designed machine.

his prevention of air contact can also be arranged by using
yer of pure paraffin oil on the surface of the cider; 3 to 5
s of oil per square yard of surface should be used.

lineral oils are better than vegetable oils, such as olive oil,
account of the susceptibility of the latter for developing a
cid taste.

he use of tallow for lining casks, to prevent excessive evapo-
on, has been advocated by Power. Many types of linings
e been used for the same purpose, especially the Fernbach

material particularly examined by Roger de la Borde. Th spraying of the interior of the barrels with paraffin wax, a widely practised in England and Switzerland, has good results as there can be no danger to the taste of the cider and the wa forms an efficient lining on the wooden staves.

Concrete Vats

These vessels have many advantages. They have practicall unlimited capacities; they are very economical in space compared with barrels; their cost of production is relatively cheap they have a very long life; their cost of upkeep is low; the maintain very constant temperatures; they are easy to clean; the loss of liquor by evaporation is negligible and the cider can be maintained in a condition quite free from air contact.

The need for the concrete foundation to be covered with a protective lining has already been discussed in an earlie chapter. In Brittany, granite vats have been used. They have proved satisfactory so long as there are no cracks in the surface, the stone contains only small amounts of iron, and the joints are well waxed. Glass tiles were widely used, the jointing being effected with potassium silicate or paraffin wax. The building and lining of concrete vats is an extremely delicat matter, and should be left to qualified technicians. The vats should be provided with all the necessary inlets and outlets provision for carbon dioxide entry, gauges, sampling cocks and fermentation locks, etc.

Warcollier mentions the fact that he has known French cider-makers and distillers who used concrete vats without a linin of any description. He has described in detail the effects on the ciders of storage under such conditions and mentions in conclusion the list of linings found satisfactory for concrete vessels paraffin wax; Betindus, Everseal, Ebon, Fernbach linings; Extreme-Orient lacquer, and certain chemicals such as magnesiun fluoride, potassium silicate, and asbestos powder.

Pressure Vats

In each factory provision should be made for a number o vats capable of holding a slight pressure not exceeding 8 lb per sq. in.

Ciders can be stored at a pressure of 4 lb. per sq. in.; th ty of the cider will be retained at its maximum value, and ntation will be very slow if several rackings have been ously carried out to remove the greater part of the yeast The cider so produced has the advantage of being always ated with carbon dioxide.

Metallic Vessels

he use of unlined metal vessels for cider-making is not to be mmended. The effect of malic acid in the presence of car- c acid is extremely powerful and cider can attack many allic surfaces with most unfortunate results. Some details rding specific metals will be given.

on.—Contact of cider with iron causes the production of n, brown and black colourations or precipitates, due to the bination of the iron with the tannins of the cider. The con- with iron may occur when apples are placed in railway gons previously used for the transport of ores; from ferru- ous earths clinging to the fruit at the time of milling; or n the water used in processing.

ron vessels should always be protected by some form of ng. Enamel surfaces are most satisfactory, but the tinning ron has the advantage of being cheap and easy to apply, ough its use is not entirely free from danger.

he features of a suitable lining have been described by enot:

a) Perfect adherence to the surface.
b) Sufficient elasticity to resist shocks.
c) Complete insolubility in fermented products.
d) Sterility and absolute impermeability.
e) A low enough melting point to ensure easy application, but high enough to prevent softening under hot summer temperatures.

hese conditions are most generally satisfied by tinning or use of special linings. For cider transport, enamelled steel ks are satisfactory and this method is largely used throughout industry. For the transport in summer of sweet cider when desired to maintain its naturally sweet condition for as long eriod as possible, it is probably best to use wooden casks, nted white. The rise in temperature in the cider will be preciably less if stored in wooden vessels than if metal casks are used, despite the fact that they may have to stand relativel high temperatures.

The production of cider for distillation is sometimes carrie out in lined iron vessels. Where the lining was weak, Warcollie had observed a retarding of fermentation due, in his view, t excessive solution of iron (0·02% iron, or 200 p.p.m.) in th ferrous state.

Tinning.—The corrosive powers of malic acid on tinned iro are increased by the presence of sulphur dioxide, even in ver small quantities. Ciders containing sulphur dioxide can hav most serious effects on tinned iron vessels. The prior solution o the tin leaves the iron exposed, whilst cases of poisoning b consumption of foods preserved in tins was, according to Jellne due to the formation of arsine from the arsenic present in th tin. Vaubel has shown that the formation of tin hydroxide ma possibly occur by the action of nascent hydrogen on the tin According to this author, soluble forms of tin are capable o causing poisoning.

Copper.—Warcollier has noted on several occasions that th presence of copper can cause various troubles in cider. A metalli taste is often noticeable when ciders have been bottled throug mineral water filling machines; or even when passed throug a cider-bottling machine that had not been properly protecte

Warcollier confirmed the presence of 500 p.p.m. of iron an 37 p.p.m. of copper in a concentrated juice made from appl juice containing 1000 p.p.m. sulphur dioxide. The metals ha dissolved from a new evaporator in which the copper had n been protected from the action of the juice. Inoculation of th diluted concentrate with a vigorous strain of pure yeasts woul not initiate the fermentation of the juice, and, indeed, fermentation did not commence until practically the whole of th iron and copper had been removed.

The taste of copper can also be contributed to the cider b the use of taps or stills fabricated from copper. The coppe content is on some occasions quite appreciable and the tast will then be extremely unpleasant and hard.

Aluminium.—Trillat, in an investigation on the effect of aluminium in the fermentation industries, noted that this meta precipitated the coloured tannin of red wine which led to more or less pronounced decolouration of the product.

rcollier examined aluminium of 98-99% purity, provided e form of strips which had been scrubbed, washed, de- ed and which were weighed before and after exposure to . The test media were:

) A non-acetic natural cider with 3·2% alcohol.
) The same cider with 1000 p.p.m. sulphur dioxide.
) The same cider acetified with 0·5% acetic acid.
) Straight apple juice, specific gravity 1·080, containing 1000 p.p.m. sulphur dioxide.
) Non-sulphited concentrated apple juice containing 80% sugar.

or each test solution, two samples were used in separate s, one metal strip being completely immersed, whilst in other flask the strip was only partially covered by the or. The strips were in contact with the various solutions for onths. (The immersed strips were 8 cm. long, and 2 cm. e, whilst the other series were 12 cm. long and the same th.) The results are given below:

Test Liquor	*Disposition of aluminium strip*	*Loss in weight of strip %*
1	Completely immersed	0·323
	Incompletely immersed	0·266
2	Completely immersed	0·420
	Incompletely immersed	0·509
3	Completely immersed	0·287
	Incompletely immersed	0·361
4	Completely immersed	0·677
	Incompletely immersed	0·734
5	Completely immersed	0·198
	Incompletely immersed	0·144

hese experiments lead to the following observations:

olution No. 1 deposited a brown material on the strip and the bottom of the test vessel. The strip became blackened he air junction with the liquid.

olution No. 2 provided a whitish deposit on the strip and in vessel, but the condition of the strip was similar to that in . 1.

olution No. 3 showed a light brown deposit.

olution No. 4 was similar to No. 1.

olution No. 5 showed a greyish black colouration on the p.

Conclusions:

(*a*) Aluminium is attacked both by apple juice and cider

(*b*) The corrosive effect is greater in the presence of sulph dioxide, i.e. in reducing conditions, and also in presence of air.

(*c*) Acetic acid does not appear to affect corrosion to a additional extent.

(*d*) Concentrated apple juice without sulphur dioxide less action on aluminium than a natural cider with 3 alcohol.

Aluminium can usefully be employed where the cider d not remain in contact with the metal for protracted periods

Glass Lined Tanks

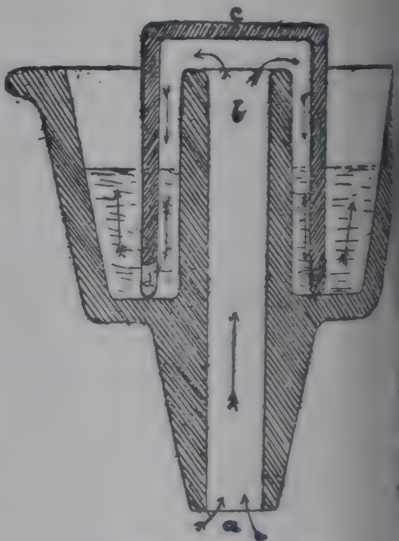


Fig. XXXIV.
French Type Bung for Fermentation Vessels

The adoption by breweries of glass lined tanks indicates the great value of such vessels for fermentation purposes. They can be cleaned and sterilised with ease and the cider industry would undoubtedly benefit by imitating the breweries in this respect. Vessels capable of holding 11 lb. pressure have been used at the Research Station at Caen. (These were fabricated by a company producing glass lined tanks at Agen.)

Seals for Fermentation Vessels

Bungs.—The vessels in which fermentation occurs shoul protected against air contact whilst at the same time allow the carbon dioxide gas to be released. A clean cloth cove with ashes or fine sand used to be employed to cover the bu hole of the cask, but the course and speed of fermentation c not be gauged by this means. Very simple forms of bungs available, constructed in wood, glass or porcelain. One Fre type is shown in Fig. XXXIV. It is composed of a central t surrounded by a small trough on which is inverted a loose c which rests on the bottom of the trough.

lower section of the cover is perforated below the liquid o facilitate the passage of the gas. The taking of the ature or sampling of the contents of the cask can be l through the central column without removing the bung.

ry simple bung can be made by fitting a loose glass tube h a bung and filling the tube with cotton wool or some material. Bungs with movable valves (Fig. XXXV) can used.

en the fermentation process is completed there is the r that acetification may ensue after active evolution of s ceased. The cask should either be kept completely full ow continuous disengagement of gas should be provided, by using a supply of artificial carbon dioxide or by g each month 1½-3 lb. sugar per 100 gallons of cider. The fermentation that ensues with the latter treatment comy protects the product from acetification, or at least it onsiderably lengthen the period of orage of the cider.

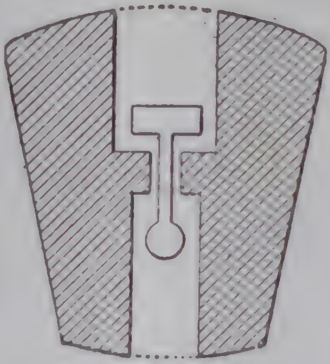


Fig. XXXV.
French Type Bung with Movable Valve

Control of Fermentation

ring the fermentation process samf cider should be withdrawn and ned in a glass for clarity and de- A superficial microscopic examn will give information as to the e of the yeasts present; an acidity will sometimes provide useful intion in cases of very rapid fermen- or the production of specialised products with unique rs, i.e. whether the fermentation is normal or if the wild are becoming dominant.

e specific gravity hydrometer should be constantly emd to follow the course of fermentation. The temperature fermenting juice should be determined and noted, tor with the gravity figures, on a card attached to each ntation vessel. It is also valuable to add to these data for the alcohol content of the cider and the sugar remainnfermented. Such data will generally be only approximate, se of the variations in chemical composition of fresh juice, but the accuracy will be sufficient for routine purposes. If the approximate figures are not sufficiently accurate, more reliabl data can be obtained by methods to be described later in th chapter on Analysis of Ciders.

TRANSLATOR'S ADDENDA

Fermentation Vessels

Wooden casks and vats are still used to a greater extent than any other form of vessel for fermentation. In recent years, however, concrete vessels have grown in popularity, especially sinc the introduction of reliable linings has rendered their use perfectly safe. A number of such linings have been used in England the chief amongst them being the Swiss product, Ebon, which has been introduced into many extremely large installation and has stood the test of time over a considerable number o years. This material was naturally unobtainable during th 1939-45 war, and several English materials were develope during that period. Prominent amongst these were the Nutraline lining and Prodorphalte. Neither of these products, however, has yet been tested so thoroughly as the Swiss materi over a long period of years. Fig. XXXVI illustrates the extern appearance of Ebon vats installed with special piping for co lection of carbon dioxide gas evolved during the fermentatio process. (The piping can be seen on the roof of the passage-wa between the two rows of tanks.) Fig. XXXVII shows the interior of an Ebon tank of 75,000 gallons capacity, built into compact structure with several other tanks to provide a tot capacity of 550,000 gallons. The whole erection is self-containe and stands by itself outside the factory premises of the Glouce tershire Cider Co. Ltd. at Wickwar. Heat insulation is speciall cared for in all such outdoor installations.

The contact of cider with metals must still be a matter fo extreme caution, but improvements in metallurgical chemistr have enabled certain new types of alloys to be introduced whic have considerably enhanced resistance to corrosion. Among these, monel metal (tin and copper alloy), and various grade of chromium-nickel steels (stainless steel) possess highl corrosion-resistant properties and are finding increasing use i cider factories for various purposes (pipe lines, pumps, bottlin

nes, small preparation vessels and centrifuge bowls).
use for large scale storage vessels is, however, entirely
ded on the grounds of excessive cost. Many acid-resisting
es have satisfactory properties, whilst tinned copper ves-
ipes and casks are still in widespread use. Silver lined
will probably be superseded by stainless steel plant.

el and other vessels and pipelines of certain minimum
sions are now being lined with plastic-type materials of
corrosion resistance, and these have proved to be ex-
ly useful in various types of cider-making plant (excluding
application to wood or concrete). Examples of such
ials are Lithcote and Prodor-Glas.

recent introduction to cider equipment has been the use
rex glass pipelines, which are very valuable from the point
w of ease of sterility. Very attractive and efficient lay-outs
e arranged, often with complicated arrangements to cover
low of liquids throughout the factory.

CHAPTER XII

POST-FERMENTATIVE CLARIFICATION

THE aim of the cider-maker should be to produce beverag that will keep for several years, and chief amongst the conditions that assure success are the maintenance of a slow, continuous fermentation, unaffected by wild yeasts or disorders any description. Cider that has completed its main fermentation should be freed from the greater part of its yeast crop an from all microbial activity. The pectin, protein and tanni compounds in the lees are capable of providing nutrient elements to these various types of organisms. The purification the fermented cider presents many difficulties. Several distin methods are available, but what suits one cider admirably wi be quite useless for another, whilst a third cider will ultimatel need the application of two treatments before it can be considered to be sound. The fundamental difficulties at this stag of the processing are due to our lack of precise knowledge the composition and interactions of many of the more compl cated compounds in the juice; their physical state is indete minate, yet of the utmost importance. We merely know tha many of these complex organic compounds are in a state unstable equilibrium, and that a very minor effect, such as th presence of a minute quantity of some inorganic salt, can completely alter their physical condition, either causing comple and instantaneous solution or a mass precipitation. On som occasions, a lowering of temperature can have the same effec

The removal of the lees and micro-organisms in the cide itself can be effected by racking, fining or filtration.

Racking

The cider must be quiescent if the racking is to be successfu Days of rain, tempest or low barometric pressure should b avoided, and rackings should be carried out on fine, clear, col days with relatively high pressure. Where possible, the cide maker should avoid long racking pipes, and should arrange h nes in such a way as to avoid all contact of the cider with s a general rule, it is advisable to rack the cider at a temure lower than that which existed during the main ferration, for by so doing the evolution of carbon dioxide gas a large extent avoided. The lower temperatures are generbtainable only by artificial refrigeration; indeed, it is certhat until the cider industry is fully equipped with ample gerating power, it will never be able to regulate its primary entations or operate the series of subsequent rackings under factory conditions.

ery unsatisfactory methods are still employed for racking. cider is splashed into the receiving barrels, the carbon ide gas is largely lost, the liquor becomes aerated. The st thereby gains a new activity and commences a further nentation in the clean barrel or vat, with consequent pretation of natural substances or the products of fermentation. cases such as these, all the benefits of racking are lost, and equivalent advantage has been gained. An unsatisfactory king does much harm to the cider for it becomes flat and nents at an accelerated speed.

t is best to rack under a slight pressure of carbon dioxide the cider should be filled into a cask which has already been d with the same gas. Ideally, several rackings should be ployed if really efficient clarification is desired. All the French er-makers of the best calibre operate two or three rackings, luding that which follows the initial keeving process. The l treatment should be carried out before the gravity has en below 1·015; this should so check the fermentation that vill continue at a very slow rate for a sufficiently long period keep the cider saturated with carbon dioxide and to contrie to the retention of its general organoleptic characters.

Fining

Normal fermentation is accompanied by a natural fining or rification of the juice or cider. The insoluble compounds fall he bottom of the fermentation vessel under their own weight, rying with them the very finely divided organic tissue disninated through the juice. The natural clarifying agents in ple juice and cider are the alcohols and acids, albumins, ctins and tannins.

It is often necessary, however, to aid the natural fining process by the addition of some material which removes from the cider the classes of compounds that cause it to remain in a cloudy and unstable condition; for example, ciders that ferment very slowly often show extreme difficulty in clarification and it is necessary to use some artificial means of removing the offending substances.

For a fining action to be successful, the fermentation must be completely arrested. If chemical antiseptics are to be used, it will be necessary to add strong doses and one difficulty arises here, in that it is almost impossible to generalise regarding the amount of sulphur dioxide or other agent to add to any given cider for complete inhibition of yeast activity. The efficiency of the sulphur dioxide will depend to a large extent on the activity of the yeast, its weight, and other factors of an indeterminable nature. A normal dose can be taken as 1½ oz. K.M.S. per 100 gallons, but Warcollier has been unable in some cases to prevent fermentation by the addition of twice this amount of sulphur dioxide.

Even if fermentation comes to a practically complete standstill by natural means, one has still to contend with the possibility of the evolution of carbon dioxide dissolved in the cider. Very minor alterations in temperature or pressure can disengage bubbles of carbon dioxide, which agitate the liquor and prevent the settling of the fining materials.

The fining process calls for a period of quiescence in the cider for ten to twenty days. Obviously, when ciders are stored under temperature conditions which are uncontrollable (i.e. as would be the case in an ordinary farm cellar) this period is too long for the maker to be sure that no carbon dioxide evolution will occur as a result of a rise in temperature. Any such carbon dioxide disengagement will inevitably prejudice the fining process. Warcollier does not recommend the use of fining on the farm except in those cases where a cider is completely unsaleable because of its thick condition, and where some drastic action must be taken to render it marketable.

Well equipped cider factories do not employ fining agents as a routine procedure but only when they have not succeeded in producing adequate clarification by means of rackings.

Successful fining is achieved only by being guided by the l character of the liquor to be treated. For each individual , it is necessary to determine both the ideal agent to use the amount to add for optimum effect. A material finally en for one specific cider will probably be quite useless when d to another product. The first action to be taken is, there- to carry out a trial on a few pints of juice to determine the mum conditions for clarification.

ning of dry ciders is relatively easy, for no account need be n of the difficulties caused by active fermentation.

he characteristics of a satisfactory fining agent are not only it should remove from the cider all solid materials in sus- ion, but also that it should leave all soluble constituents pletely unaffected; the cider should not acquire from the ng materials any foreign constituent or taste, nor should the ng agent alter or remove any of the principal constituents of cider. It should be capable of forming a heavy deposit of ll volume, which collects and settles rapidly.

he main principles of the fining process have been set out wine making by Mathieu, and are given here in detail:

) The slower the settling of the deposit, the clearer will be final product. This axiom, however, must be treated with tion, for a too extensive period of fining may introduce diffi- ies due to the disintegration of the deposit and its dissemi- ion through the cider.

i) The efficiency of fining increases with the coagulating ver of the cider and of the fining agent. In the cider, the rative constituents are tannin, alcohol and mineral salts; on contrary, fining is inhibited by free acids, sugars, glycerin, ns, etc. The usual fining agents, arranged in ascending order fficiency are isinglass, gelatin, egg albumin, blood albumin, ein.

iii) Other factors being similar, the clarification becomes re rapid as the dose of the fining agent is increased; the ume of cider containing the deposit is proportional to the ount of fining agent added.

iv) The addition of tannin in doses varying from ·005% to 5% (¾-2½ oz./100 gallons) adds to the efficiency of a fining tment.

v) The preparation of the fining material has an important ct on its ultimate efficiency. Thus, isinglass and gelatin, prepared in warm water, work more rapidly and leave smalle quantities of deposit than when a cold solution is prepared.

(vi) Marine salt activates the fining process, but in so doin a certain amount of chlorine enters the juice and this must b carefully estimated and kept below 0·1 % or the taste will become noticeable.

(vii) For ciders with low tannin contents, isinglass should b used at the rate of ·002%-·003% (⅓-½ oz./100 gallons). Suc a fining is extremely gentle and appears to do little more tha precipitate some of the tannins of the cider.

Treatment with 1½-2½ oz./100 gallons of gelatin, prepared i hot water, forms much less deposit than when the gelatin i made up in cold water. The clarification is rapid, but unfortunately the colour of the cider is considerably reduced. Gelati fining is widely employed in Germany and Switzerland wher pale ciders are acceptable.

Egg white or dried egg albumin (¾-1¼ oz./100 gallons can be used for ordinary ciders.

Dried blood, employed at the rate of 2½ oz./100 gallons is diluted and used for ciders which call for very rapi fining.

Casein forms a deposit rather too quickly to give the bes clarification. If added at the rate of 1-1½ oz./100 gallons, wit violent agitation, it will rapidly clarify the product.

(viii) The addition of tannin should be carried out abou three days before the completion of the fining process. If it i added immediately before the actual fining agent is introduce it will exert a slow effect on the colloids in the cider and wi only form its own specific deposit after the lees have forme leaving a blue coloured cider.

(ix) The beating-up of the fining agent with the cider by mechanical means (a series of blades or paddles in a cask an operated mechanically) should be employed merely to mix th coagulant into the cider, and the agitation should cease as soo as the deposit is formed.

(x) Ciders standing on their lees should not be fined, becaus of the possibility of gas formation.

(xi) When the lees have formed, the cider should be remove as soon as possible. The clarity of the supernatant liquor shoul be carefully checked before racking off.

(xii) Fining, as a mere method of clarification, can often be replaced by filtration with excellent results.

(xiii) Albumen or egg white can be used at the rate of 4-8 egg whites/100 gallons, according as one needs a gentle or accentuated fining action. The egg white is dissolved in warm water (1 pint of water for 5 whites of egg). The solution is well beaten to obtain a frothy consistency and is run slowly into the cider, beating it vigorously all the time.

Commercial dried albumin can be similarly used, at the rate of ¾-1¼ oz./100 gallons. If albumin alone does not give satisfactory results, the cider should be treated first with ¾ oz/100 gallons of tannin.

(xiv) Casein is sold as a light, white powder which can be prepared for use in exactly the same way as for egg white. It coagulates very easily in cider under the influence of the natural acidity of the product. For the two types of fining mentioned above, casein should be employed at the rate of 1-1½ oz./100 gallons.

(xv) Tannins should be soluble in water or alcohol and those that are only soluble in ether should be rejected. The solid material must be dissolved in warm water and not added direct. The usual dose is ¾-2½ oz./100 gallons.

(xvi) Isinglass can often be successfully used. It should be soaked in a little cold water for 24 hours before needed, and complete solution can then be achieved by continual stirring in a convenient form of vessel. At the rate of ⅓-½ oz./100 gallons, isinglass gives good results, but it is even more effective if tannin has been added previously at the rate of ¾ oz./100 gallons. A Russian sturgeon product is very active, but on account of its expense it is usually replaced by the product from another fish, the silurus. The fish product in this case is light brown in colour and is prepared in the form of practically transparent platelets. This agent is used in hot water at the rate of ¾ oz./100 gallons.

(xvii) Gelatin should be soaked for several hours with a small volume of cold water. More water is then added and the temperature gradually raised. Solution will occur slowly if constant stirring is undertaken. The water solution is diluted with cider and this is vigorously mixed into the main bulk of cider to be fined.

(xviii) On no account should oak bark, blood or milk b used on any substance that has not been specifically recommended. Some ciders can be clarified by the mere addition c a substance such as Kaolin, Spanish earth, talcum powder o silica flour, which absorb on their surface the materials responsible for the cloudiness of the ciders.

(xix) In whatever manner the fining has been achieved, i must always be quickly followed by a racking operation t remove the clarified product from the lees.

(xx) The process of fining is often accused of denaturing cider, and of causing a deterioration in its taste and sometime in its colour. It must be emphasised that if preliminary tes are not carried out to determine the best agent for a particula cider, and the minimum quantity to employ, there is a grav danger of some part of the clarifying agent remaining in th cider and providing a nutritive base for organisms through i nitrogen content.

Filtration

The process of filtration should only be applied to partl clarified ciders. Only if this condition is fulfilled can the produc be satisfactorily filtered to a brilliant condition without losin any of its character and fullness of flavour.

Filtration is recommended for ciders which, despite severa rackings, still remain cloudy, or in which the fining process ha been ineffective, as well as for practically dry ciders. Beverag which are being prepared for ultimate bottling should definitel be filtered. Products in cask should also be similarly treated they are to be consumed shortly after the filtration process.

The cider-maker should aim at offering for sale a produc similar to beer in its clarity and light carbonation.

The filter will slightly fatigue a cider, giving it a drier tas and removing, if only temporarily, its soft character. To minimise these disadvantages, it is essential to avoid contact wit air and to retain as much dissolved carbon dioxide as possib during the process. The filtered ciders regain the greater pa of their character a few days after filtration, but there is alwa a little less intensity of flavour in the filtered products.

Principle of Filtration.—Filtration is the process whereby cloudy liquid passes through a porous material and is relieve f its suspended contents, thereby being converted into a pro-uct with a brilliant transparency. The actual operation of the rocess is dependent on the nature of the filtering medium, the liquid to be filtered, and the suspended materials contained herein. The temperature of the juice also has some significance. To indicate the complexity of the problem, an abstract is given of a note on the subject by Appert (Notes on filtration and its application in the cider industry. *Annals of Brewing and Distillery*, 10th January 1926).

The filtration of a cloudy liquor is effected by causing it to pass through a porous mass of material such as sand, infusorial earth, polished porcelain, cellulose or other fibre paste, on which the solid particles causing the cloudiness are deposited. The porous material s the filtering medium and after traversing the mass, the liquid becomes clear. In due course, the solids causing the cloudiness will choke the filter and the flow of liquor will gradually decrease until eventually it ceases entirely. The filter is then said to be exhausted, and to continue the filtration a new filter mass must be prepared, using either the old material after being washed thoroughly, or a completely new batch of filtering medium.

The first potable liquor to be filtered on a commercial scale was beer which had been prepared by bottom fermentation. The results were perfectly satisfactory. However, when the method was applied to cider and wine and top fermentation beers, very unsatisfactory results were obtained and eventually it was found that the temperature of the liquor entering the filter was of prime importance. Satisfactory filtration with the type of beer mentioned first was due to its temperature being about 0°C., whilst the other liquors were filtered at elevated temperatures of 10-18°C. When these wines and ciders were reduced in temperature to 0°C. their filtration was easily accomplished.

The application of refrigeration to the beverage so changes its composition that the filtering medium can remove more easily and effectively those constituents that are responsible for the cloudiness. Beverages such as are now under consideration are composed of varying proportions of water, alcohol, acids, minerals, ethers and colloids. The colloids are of very great importance in the filtration process. They contribute directly to the retention of the head, and they confer body on the drink and that soft character so desirable in a quality product. Colloids, however, are responsible for the difficulties encountered in filtering the product to a brilliant condition. Two classes of colloids may be considered to exist in these fruit products. They differ largely in their physical state. One class (designated A for convenience) are hydrosols, and would give perfect clear solutions if they were the only colloids present in the juice cider. The second type of colloids (B) are hydrogels, and are th direct cause of cloudiness and opalescence. This arbitrary separatio of naturally occurring colloids into these two distinct groups is n scientifically true and is only adopted for the purpose of more clearl presenting the implications of certain scientific principles later. a matter of actual fact, the colloidal compounds in these beverag before filtration are present in a very large number of varying form with hydrogels and hydrosols as the two extremes and with a almost infinite number of gradations between them.

The relative proportion of colloids in states A and B are not fix in any given liquor. They can be influenced by the *p*H, temperatur concentration, electrical state and the conditions by which the pr duct has been previously prepared. In a given liquid and with ce tain prescribed physico-chemical conditions, there would be as mar colloids in state A as in state B. This can be shown by a simple e periment. A beer showing a perfect clarity after filtration will becom cloudy if subjected to a lower temperature. This cooling effect h transformed into state B some of the colloids that were in state previously, and this change in state has caused a definite flocculatio Inversely, the warming of the beer to the temperature at which was originally filtered restores the clarity by the return of the colloids from state B to state A.

The filter medium does not effect its clarifying action by acti like a sieve, even although in a tight filter the fibres are packed an exceedingly compact manner. The spaces in the filter mass a thousands of times greater than the largest colloidal micelles encou tered in state B, and straightforward mechanical action cannot b considered as accounting for the precise action of the filter.

The filtering medium, although so tightly compressed, actual exposes an enormous surface area to the liquor passing through i and knowing, as we now do, that most substances react only throug contact of their surfaces with each other, these reactions are inte sified and enormously magnified by the surface area of the fibres the filter. Again, such surface actions are known to be greatly accel rated by raising the temperature.

Consideration can now be given to the precise reactions in th filtration process. A cloudy cider, wine or beer at 10°C. contai colloids in all forms between states A and B. On making conta with the filter medium, electrical changes occur which, by destroyi the equilibrium of the colloidal micelles in the liquor, induce a pr cipitation of the colloids on the walls of the individual fibres of th medium. It would seem as if the surfaces of the filter material a e a magnet, for not only do they attract the colloidal micelles but ce the surfaces have contacted each other, the colloids are powerlly retained on the filter. Such a phenomenon is known as *adsorption.* Colloids of type A are more resistant to adsorption than type B. he higher the temperature, the greater will be the amount of pe A colloids that will be adsorbed, relative to those of type B. he interstices of the filter soon become obstructed by a layer of olloidal substances. The flow through the filter is greatly retarded ntil it becomes so slow as to be uneconomical to proceed. The filter exhausted, or it would be more appropriate to say that it has ecome inactivated or neutralised. The higher the temperature of ltration, the greater will be the removal of colloidal substances by dsorption, and consequently the greater will be the loss of these haracteristics so important in connexion with the body and organoeptic qualities of the beverage. The filter in these circumstances has double duty to perform: it must first separate the flocculable olloids and then immediately adsorb them on its surface area. Now, he cooling of the liquor to 0°C. before filtration will effect one of he duties and thus relieve the filter of that part of its responsibility. The low temperature will flocculate the colloids sensitive to such emperatures, and the liquor arrives at the filter with a composition of such a nature that it will become perfectly clear when the filter medium has merely adsorbed the colloids that have been flocculated by the low temperature before the filtration. Again, it has been seen that low temperatures retard surface action, but in the cases in which we are concerned here, the colloids in state B will be very easily adsorbed and the capacity of the pulp for adsorption is sufficiently powerful to retain these colloids. On the other hand, the adsorptive power will scarcely be sufficient to provoke a complementary dissociation of the colloid after passage through the filter. If such an action does occur, it will be of feeble intensity. Thus, the only materials removed from the filtered liquid will be those colloids that are converted to type B under the influence of the low temperatures of the initial cooling treatment. The proportion of these is considerably less than those that are flocculated in and by the filter at a high temperature. Thus, the filter becomes clogged at a much slower rate and the filtered liquid retains to a much greater extent its body, softness and general taste characteristics.

Experience confirms these theoretical statements, especially in the case of top fermentation beers that are usually very bitter. The bitterness is due to colloidal combinations of the lupulin of hops with nitrogenous compounds. If filtration is effected without preliminary cooling, the liquor will be obtained in a perfectly clear condition, but it will have lost the greater part of its bitterness, so much so that its devotees will be unable to recognise it. If, howev the beer is filtered after cooling, it will retain its brilliancy and character as a beverage; the loss of bitterness is insignificant a practically undetectable.

In the filtration process, the micro-organisms become adsorb with the colloids and are entrained in the adsorbed colloi material. Complete sterility is not achieved, however, by t means, and the presence of even one yeast cell in the filtrate c cause renewed fermentation, if conditions for growth are suitab Beer is a liquor rich in nitrogenous substances which are assimila by the yeasts and other organisms. Such nitrogenous compounds a mostly in the colloidal state. For this reason, any filtration treatm that does not change the composition of the beer will not ensure it any other property than a clarity that will last for a maximum three weeks. The position is quite otherwise for cider and wine. Th liquids are poorly supplied with nitrogenous compounds, and th colloids are mostly pectinous in nature and not affected by yea Apart from the inhibiting effect on yeast growth of the alcohol c tent of the product, the yeast cells which pass through the filter fi themselves in a medium which virtually starves them and conta insufficient nutrients for their normal development. In this way, c can explain the stability of wines and ciders during months a years after they have been filtered subsequent to a prelimin cooling. For this reason, it is important to emphasise again the gr value of this cooling process prior to filtration, so that ciders sh retain their full character and hygienic properties.

Types of Filters

Three main types of filters have been developed; i.e. clo pulp and mineral earth (kieselguhr or diatomaceous earth).

Cloth Filters.—The simplest forms were made of paper, eit used smooth or fluted. They were quickly replaced by pads cotton or hemp material, which in turn gave place to m efficient types which protected the juice from contact with a e.g. Malvezin, Girondin, Tottereau, Gasquet, Daubron, c The Philippe type of filters are equally well known in Fran The liquor to be filtered is led into the body of the filter. It fl around the bags that are fitted within, and passing through t filter material is led away through an outlet pipe. The impu ties in the cider are collected on the surface of the bags and a removed from time to time through a vent in the bottom the filter.

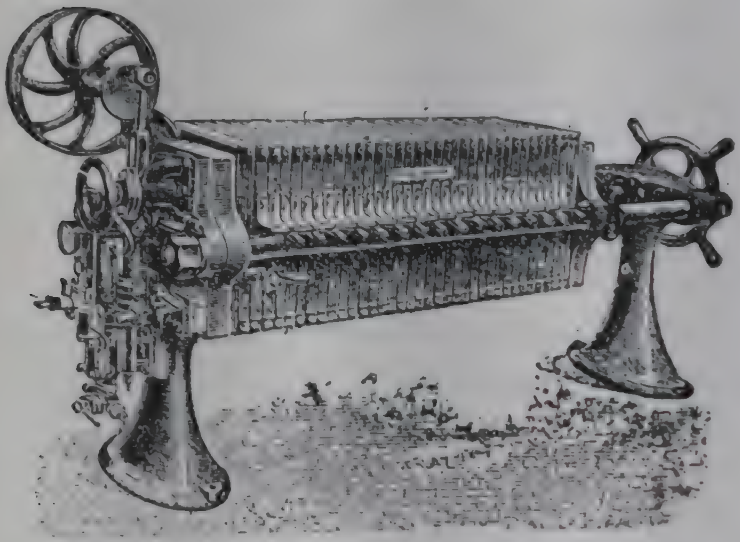


FIG. XXXVIII. French Philippe Filter Press

The Philippe filter press, which is specially suitable for very ick ciders or lees, is composed of a number of wooden plates nd frames, covered with filter cloths and suspended on a steel runway (Fig. XXXVIII). The Simoneton filters are of varied construction. The *Fortior* has double concentric plates, separated by wicker or metal structures. The filter surfaces can be coated with an infusorial earth (Fig. XXXIX). In the Simoneton filter press, the plates have been replaced by cloths which are much easier to clean; they are separated one from another by wooden distance pieces which are grooved and perforated.

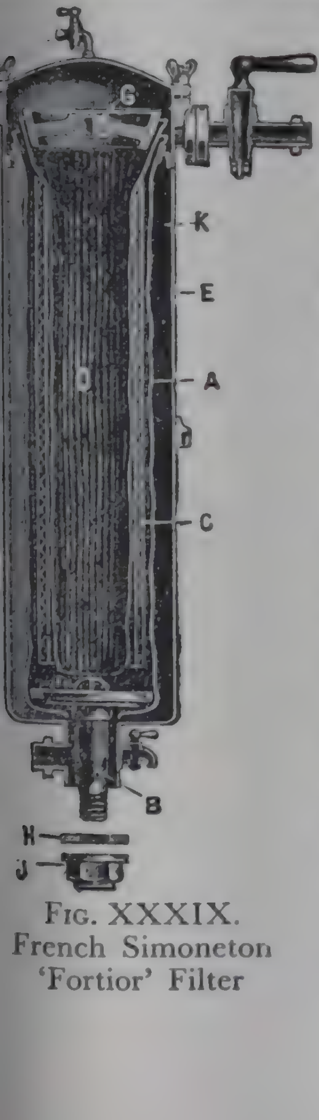


FIG. XXXIX. French Simoneton 'Fortior' Filter

Filters with Cotton Pads.—The *Universal* type made by Simoneton is in a special class. The filtering medium, instead of being quite thin, has a thickness of about two inches. Essentially, this filter is composed of a filtering candle formed by a large number of cotton washers, centrally perforated, these being placed over a tubular centre piece into which the clarified product can percolate and be led away. These washers are tightly compressed between two end-pieces and the whole 'candle' is enclosed in a cylindrical metal vessel. Such a filte is of use for ciders which have already been clarified to som extent and in which only an opalescence remains to b removed.

Filters using Cellulose or Cotton Pulp.—Very many such filte are constructed and mention can be made only of a few of th chief types.

The *Simplex* filter of the firm of Rojat is composed of a centra perforated cylinder, embedded in a tightly compressed mass pulp, which has been soaked in water and pressed around th cylinder by hand. The pulp, retained within a similarly pe forated outer cylinder, forms the filtering medium. The cider led to the central vessel, forced outwards through the pulp b pressure, and flows away through the outer perforated surfac

Generally speaking, pulp filters become choked rather quickl on account of their surface being relatively small and also b cause the lees from the cider are deposited on the surface the pulp and accumulate there. Such filters, however, are ex tremely valuable for the clarification of ciders which merel need 'polishing'; products retaining appreciable quantities solids should always undergo a preliminary clarification befor attempting to pass them through the pulp filter.

The *Lucas* filter comprises a series of plates which are covere with the filter pulp which has been mixed to a paste with wate An alternative form of this filter uses discs made from special prepared resistant metal; the discs are perforated with nume ous holes of 2 mm. (approx. $\frac{1}{12}$ inch diameter), and betwee each is placed a porcelain spacing plate.

In the *Enzinger* filter, the pulp is built up on open met frames strengthened with cross-pieces, the pulp being con pressed in a special device.

In England, much use is made of pulp for filtration, b cotton pulp is preferred to that made from paper. Pulp ma from rags is undoubtedly the very best that is available f cider filtration.

The *Cirier-Pavard* filters use very pure paper pulp.

Pulp filters are operated by air or carbon dioxide pressu or by the use of a centrifugal or piston pump fitted with a b pass to regulate the pressure. One further type that should mentioned is that of the *Etablissements Kendall* for use with cide o be carbonated at low temperatures (see Fig. LXVII for a nodern Kendall filter).

The filter pulp should be washed after each charge has become exhausted. The washer should be automatic and should provide a clean, well-disintegrated product. On the other hand, too violent a beating action is undesirable.

Filters using Mineral Materials.—These filters utilise a variety of materials, mostly of a mineral nature.

The *Meignen* filter uses an earthy base contained in a series of bags, filtration being effected by pumping the cider through the medium.

The *Asbestos* filter is composed of an asbestos paste, placed on horizontal plates.

Other filters employ a paste of cellulose mixed with diatomaceous earth; the material is placed on a series of metal discs pressed tightly together and separated from each other by silvered copper spacers.

The *Mallie* filter consists of a series of porcelain filtering elements contained in a metal vessel. The cider passes through the exterior to the interior of the element. Ciders can be completely sterilised by this type of filter, but its output is very small.

Choice of Filter

For very thick ciders, the only type of filter that has a satisfactory output is the cloth filter with a large surface area. Final, complete clarification must, however, be provided by another filtration of a finer nature; i.e. either cloth or pulp.

A filter using diatomaceous earth can completely inhibit fermentation over a period of one month in a cider of gravity 1·045 which has previously been keeved (*Girondin* filter).

Pulp filtration provides, in general, brilliant ciders with a clarity superior to that of the cloth type. It can also effect a considerable reduction in the micro-organism count by removing bacteria. Those filters that make use of mineral materials as a medium can be regarded as providing a sterile product.

Use of Filters

Contact with air should be avoided and the applied pressure must be constant. Special pumps are devised to satisfy this condition. The Daubron automatic pump has regulators to maintain absolutely constant pressure; i.e. the regulation of the pressure in the reservoir is operated directly by the varyin suction in the pump, instead of being operated by a valve whic is inserted in the body of the compressor.

Ciders that have not undergone a clarification process c which have been keeved only with difficulty and are still ver cloudy, must be filtered. The gravity will usually be betwee 1·035-1·030, and cloth filters will be more efficacious than th pulp type.

Ciders provided for the hotel and restaurant should be fil tered before being bottled. They should be brightly sparklin and possess a gravity of about 1·005.

Translator's Addenda

Filters

A very wide range of filters are now available for the filtratio of cider at various stages of its history. During the fermentatio process, cider should always be centrifuged before being filtere as the life of the filter packing is increased to an astonishin extent by so doing. Ciders, however, that have clarified to a appreciable extent can be dealt with by almost any form c filter, for the filtration media are available in many grade suitable either for dealing with liquors of differing clarity c to provide filtrates with varying minimum yeast population The following filters are illustrated as examples of the variou types which are available from British manufacturers.

(i) *Pulp Filter*.—Fig. XL shows a large sized filter from th firm of Geo. Adlam & Sons Ltd., suitable for the filtration cider retaining an appreciable degree of cloudiness. The filte is made in two sections so that one half can be operated whils the other half is being re-packed. Large outputs up to 2,00 gallons per hour can be achieved. The construction is generall made in acid-resisting bronze, but the plates can be lined wit various materials (i.e. Lithcote or Prodor-Glas).

(ii) *Plate and Frame Filter*.—A Johnson filter is illustrated i Fig. XLI. This machine gives an excellent performance wit cider. A filter-aid of the diatomaceous earth type is used and coated on to the cloths by circulation of the cider (in whic the filter-aid has been previously stirred) until the require egree of brilliancy has been achieved. Filters of this construc- on are particularly suitable for the filtration of syrups, and ugar syrup can be relieved of the greater part of its yeast by his means. The machine shown in Fig. XLI is of the closed elivery type.

(iii) *Metafilter.*—In Fig. XLII can be seen a Metafilter cap- ble of dealing with 2,000-3,000 gallons per hour of cider. It is uilt entirely of stainless steel and is equipped with a motor riven GS Mono Pump which carries a hand-operated by-pass or the adjustment of pressure to suit requirements. All valves re of the Saunders type, thus ensuring the contact of the cider vith no material but stainless steel and rubber in the filtering rocess. The model shown in the illustration is portable.

(iv) *Stellar Filter.*—The latest introduction to British filtra- ion plant is the Stellar filter (Fig. XLIII) of Bell Bros. Domestic) Ltd. which is based on the use of Kieselguhr nd which can be used for clarification or sterilisation of apple uice or cider.

(v) *Sheet Filters.*—(*a*) Fig. XLIV represents a large sheet filter made by British Filters Ltd. in which the plates are coated with Prodor-Glas. Sheets of all porosities can be obtained for use with this filter, which has modern lines of design and is very efficient in operation.

(*b*) Carlson filters are the direct descendants of the world-famous Seitz filters which originated in Germany and made possible the cold method of processing unfermented apple juice. These filters can be made in two sections, one for clarifying and the other for sterilising the juice (Fig. XLV). Extremely large gallonages of cider and apple juice are annually filtered through these machines.

Filtering media have been brought to a high state of perfection in recent years. Sheets of a wide range of porosity are manufactured by Messrs. British Filters Ltd., John C. Carlson Ltd., Farrow & Jackson Ltd., T. B. Ford Ltd., A. Hirsch Ltd., S. H. Hodgkinson Ltd., and others, whilst several grades of diatomaceous earth (Celite, Dicalite and Metasil) answer most cider filtering problems.

CHAPTER XIII

PRESERVATION OF CIDER

Pasteurisation

Long term storage of cider is dependent on the prevention the development of parasitic micro-organisms, and pasteurisation is one of the methods employed for this purpose. Th method has many attractive features, for if it is properly employed the ciders acquire almost unlimited keeping propertie without simultaneously undergoing any appreciable change i their composition. The process can be applied either to swee or dry ciders at gravities between 1·025-1·010. The first trial were due to Lechartier who found that at temperatures of 55°C satisfactory control of yeast action was achieved, although th ciders, in bottles or casks, acquired a cooked taste; this, however, largely disappeared during subsequent fermentation.

Warcollier examined the details of processing for sweet an dry cider in bottles. In his view, a temperature of 60°C. fo 2 minutes is usually sufficient to destroy the yeasts. Howeve when the fixed acidity of the cider falls below 0·15% the tim of pasteurisation must be extended to 5-8 minutes, or alternatively, the conditions must be changed to 1 minute's heatin at 65°C.

Warcollier also showed that pasteurisation can cause the precipitation of pectin or form a persistent clouding of the cider In every case the fresh, fruity flavour was diminished in intensity. The subsequent fermentation of the cider, whilst causin the disappearance of the cooked taste, did not result in a retur of the original bouquet of the product. More recent experiments have indicated that if a temperature of 65°C. is maintained, the cooked taste can be avoided if the heating an cooling processes are carried out in the absence of air.

The treatment of ciders that show a tendency to darken mu be carefully controlled to avoid air contact during the operations of heating and cooling.

Pasteurisation into Casks.—The pasteurisation of wines by traelling machines is not similarly applied in the cider industry.

Pasteurisers are composed essentially of two parts, a heating lement and a regenerator (heat exchanger). The regenerator used in all modern machines as much for the simplicity of its onstruction as for the considerable economy in fuel effected by s use. A machine without a regenerator consumes twelve to fteen times as much heat as a machine which is fitted in this vay. Once the machine is in operation, regeneration consists n utilising the heat of the liquid that issues from the heater for he heating of the cold liquor, and at the same time to utilise he cold ingoing liquid for the cooling of the pasteurised proluct. In other words, the liquors exchange their heat contents y transfer across the walls of the machine, but without becoming mixed.

In an efficient apparatus, the liquid to be pasteurised arrives t the heating element at a temperature very near to that of pasteurisation, and only a very small extra degree of heating s needed.

Ideal conditions of pasteurisation call for a gradual application of heat; a smooth, steady flow of the product through the machines; a slow, progressive cooling of the heated cider; and the avoidance of air contact at any stage of the process.

Pasteurisers are made either with coils, nests of calandria-type tubes, cylindrical heating chambers, or, lastly, with sets of adjacent plates suitably shaped to allow the flow of liquids between them. In 1920, Warcollier utilised a Salvator machine made by the Compagnie Générale Aérodhydraulique. In this pasteuriser the regenerator was composed of two quite independent sets of tubes, arranged in spiral fashion around a central spindle. The heater was made of tinned copper immersed in a square waterbath containing hot water.

The casks were previously sterilised by steam for one hour and during the cooling operation the bunghole was protected by a piece of cloth soaked in concentrated sodium bisulphite solution. Pasteurisation was effected in this case at 75-80°C., the cider being cooled before being filled into the casks through a tube leading to the bottom of the vessel. The full vessels were immediately closed with sterile bungs. Ciders with gravities of 1·020, and treated in this manner, fermented in the casks and had obviously not been effectively treated. The deficiency the treatment could not be traced to the pasteuriser, for it w known by laboratory tests that the apparatus did actually d liver a sterile product. The recommencement of fermentati was eventually shown to be due to insterility in the cas themselves.

The experiments of Warcollier also drew attention to t difficulties which may be caused by the evolution of carb dioxide gas dissolved in the cider. It is necessary to arrange f some mechanism whereby the disengagement of gas is regulat in such a way that the gas can be re-dissolved in the cider su sequent to its pasteurisation.

Pasteurisation in bottles.—The bottles are filled, corked a wired or provided with fitments specially designed for t purpose; they are then placed in the heating vessel in su a way that no bottle is in direct contact with its surfac This can be achieved by using a vessel with a false botto or by placing cloth or wooden slats on the bottom of the vess The water is heated slowly and the temperature raised un a thermometer immersed in a control bottle of water sho 65°C. The level of water in the waterbath should be just bel the corks in the bottles so that there is no danger of water bei drawn into the bottles when they cool. During the heating, t corks allow excess liquid to escape, but during the cooling pr cess in the water bath the corks are drawn tight, and after t bottles have been removed from the pasteurisation vessel t corks are secured and the bottles laid on their sides in a cell

Large scale pasteurisation is effected by machines devised f such a purpose by the firms of Gasquet, Malvezin, etc.

Pasteurisation in bottle is advisable for sweet ciders, espec ally when such products have to be subjected to long journe or exposed to high temperatures.

Freezing

Lechartier has examined the possibility of freezing cider −3°C. or −4°C., so as to obtain a concentration of the produ by a removal of water in the form of ice. By prolonging t action of freezing, an accentuated ice production can be p duced, and beverages with fuller flavours and higher graviti can be made.

Commencing with a cider of gravity 1·010 and 3·75% alcohol weight, Lechartier was able to produce the following proucts:

(*a*) a cider with gravity 1·016 and 5·95% alcohol
(*b*) a liquor „ „ 1·002 and 0·71% alcohol
(*c*) a liquor „ „ 1·000 and 0·25% alcohol

Fraction (*a*) represented a full bodied cider of high quality. Descours-Desacres has reached similar conclusions by small-ale experimentation.

The process had not been commercially adopted in 1928, for he provision of freezing apparatus was an expensive matter. would only be economic to use this procedure in installations here complete cooling apparatus is installed, which can be ointly used for the maintenance of low temperatures in the der cellars and for the freezing of the fermented ciders.

Centrifugation

In 1922, Warcollier developed the use of a supercentrifuge or the stabilisation of cider which still retained some natural weetness. By employing a laboratory machine of the Sharples ype, rotating at 36,000 r.p.m. and subjecting the cider to a entrifugal force equal to 36,000 times that of gravity, the folowing observations were made:

(*a*) All cloudy samples of cider, whether comprising naturlly sweet ciders with gravities ranging from 1·040-1·055, or ompletely dry products with gravities practically down to ·000, were clarified to a brilliant condition.

(*b*) Ciders centrifuged in the presence of air showed a tendency to darken on account of the aeration received in their passage through the machines.

(*c*) Ciders centrifuged in the presence of carbon dioxide gas retained their normal colour.

(*d*) Ciders with gravities between 1·030-1·005 inoculated with ultures of active yeasts became brilliantly clear after centriuging. Incubation of samples of the ciders at 25°C. showed hat the centrifuge had removed most of the yeasts and had 'paralysed' those that were left in the cider. Microscopic examnation was unable to show the presence of any living cells in he cider after its passage through the centrifuge.

(*e*) Centrifuging an oily or ropy cider removes its viscous nature and the product regains its normal qualities. In the cases, it is essential to centrifuge in the presence of carbo dioxide gas.

In 1926, Warcollier carried out a series of trials in cid factories in France with a large Sharples supercentrifuge. Th machine possessed a considerable output and was fitted wit a carbon dioxide device which maintained the cider in an a mosphere of carbon dioxide throughout. Six months after trea ment the cider had thrown a slight deposit, and retained a ver fine flavour.

A cider with a gravity of 1·042 centrifuged in the sam machine was notable for the extremely slow, subsequent lo of sugar and the freshness of its taste over many months stora in wood without topping up. The centrifugation had apparent protected the cider from the action of parasitic organisms, matter of extreme importance in the storage of cider (see Fig XLVIII and XLIX).

Refrigeration

In just the same way as it has been said that fermentati at low temperatures is essential for the production of a goo cider, so it can be laid down as an axiom for cider-makers th low temperature storage (below 10°C.) is essential for the mai tenance of quality so that the secondary fermentation persis over a long period. Low temperature storage is also invaluab for dry ciders, for at temperatures between 6-8°C., or at an rate, below 10°C., the stored products can be held free fro deleterious effects due to extraneous organisms.

Other advantages in low temperature storage include th improvement in flavour and clarification due to this metho and its employment rarely calls for the adoption of any supp mentary use of preservatives.

Carbon Dioxide

The use of carbon dioxide for the storage of cider in cas has already been mentioned. The presence of the gas preve the darkening of the cider, and inhibits the development aerobic organisms, such as *Mycoderma vini*, or *Mycoderma ac* (acetic bacteria) which provoke the acetification of ciders wi e simultaneous formation on their surface of a thick film nown as 'vinegar mother'.

Storage in the presence of carbon dioxide will not prevent e development of anaerobic bacteria if other conditions for rowth are favourable. The methods by which this disadvantage an be overcome are discussed later.

It is known that an excess pressure of carbon dioxide applied o a fermenting liquor retards the yeast growth and consequently slows down the rate of fermentation. The storage of eer in vessels capable of both being cooled and held under onsiderable carbon dioxide pressure is practised in the brewing ndustry, and cider storage in similar conditions should be of nterest to cider-makers. The ciders should not be stored under ressure until one racking has occurred, so that the liquors etain only a small number of yeasts and are eventually maintained in an atmosphere completely devoid of oxygen. Enamelled metal tanks are more suitable than wood for this type of torage.

Storage of Cider on Ullage

Ciders stored for six to twelve months in wooden vessels of about 350 gallon capacity always show uncertain keeping properties. In Normandy, where factories are generally supplied with vessels of this size, the ciders often become 'hard', i.e. acetic. It would be a more acceptable procedure to rack the cider into smaller vessels, say of 120 gallon capacity, so that the time during which the cider remains on ullage will be kept at an absolute minimum.

When casks or vats are being emptied over an appreciable period of time, several methods are available whereby the quality of the cider can be maintained:

(*a*) Use of carbon dioxide.

(*b*) Addition of a small quantity of sugar to each cask whenever necessary to ensure the evolution of a slight but steady stream of gas.

(*c*) Provision of a layer of paraffin oil about $\frac{1}{10}$ - $\frac{1}{12}$ inch thick on the surface of the cider.

With vats of 350 gallon capacity, it is an advantage to fit the tap for withdrawing the liquid at about one third of the way down the cask. When the level of the cider falls, the tap is lowered to a half-way position and so on. The cask can thus h emptied without disturbing the lower bulk of liquor or the lee

All vessels from which cider is being withdrawn should b fitted with some appliance for the sterilisation of the air whic must enter the vessel as the cider is removed. Dilute sodiu bisulphite can be used for this purpose, or a mixture of cotto and powdered alkaline bisulphite.

The so-called air filters or purifiers for fitting to casks fro which cider is being continually withdrawn prevent the acce to the cider of organisms from the outside atmosphere, but the cannot provide any protection from the organisms which a practically certain to be present in the cider itself.

Bottling of Naturally Sparkling Ciders

Bottling is a perfect means of conserving cider, and whil the subject of bottling by commercial methods will be deferre to a later chapter, the principles of farm bottling without speci machinery will be dealt with in this section.

Bottled ciders should be clean, fully flavoured and with good aroma, sweet or dry according to the taste of the consume not too alcoholic, and show the correct degree and type of g evolution on being poured out.

Insufficient care is generally taken in the bottling proces The ciders are bottled too soon, with eventual breakage of t bottles as a possible result; or bottling is delayed until too lat producing flat ciders as a consequence. Even if the cider-mak does choose the right time for bottling his product, the subs quent results are variable and unpredictable, the bottles var ing amongst themselves, some opening explosively whilst neig bouring bottles show no pressure whatever and the cider its has lost its good qualities.

Many conditions must be satisfied to obtain an ideal bottlin Only ciders that have been perfectly clarified should be co sidered for this purpose. Filtration is advisable in all cases, b fining can be adopted if absolutely necessary. Given a cider a perfect condition of clarity, it is essential that it should filled into bottles in such a way that there is no contact with a The cider should be run into the bottle by a tube which reach to the bottom of the container, thus avoiding loss of gas. If th precaution is omitted, the air will activate the yeasts, there w

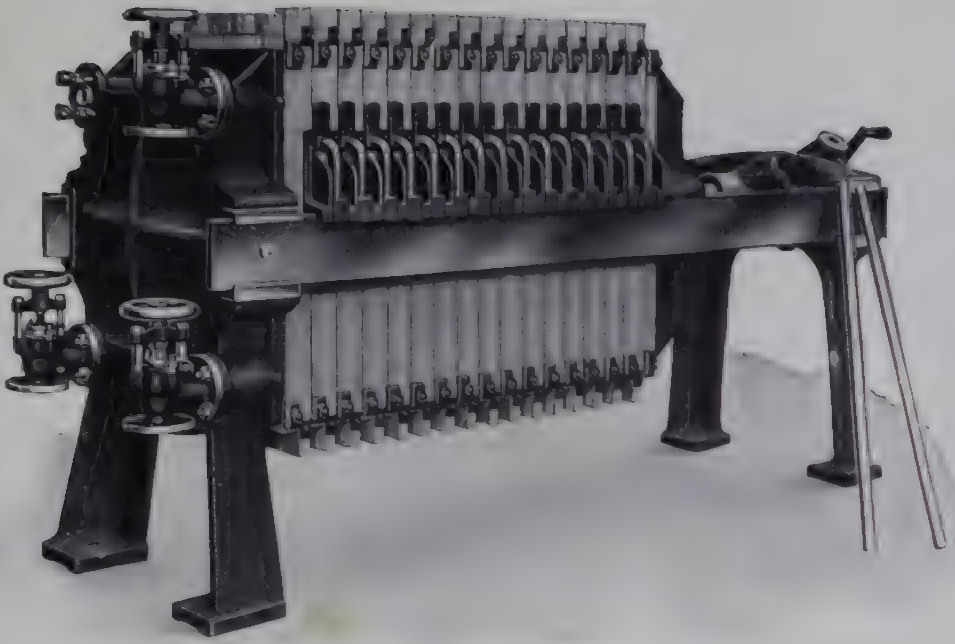


Fig. XLI. Johnson Plate and Frame Filter
(closed delivery type)

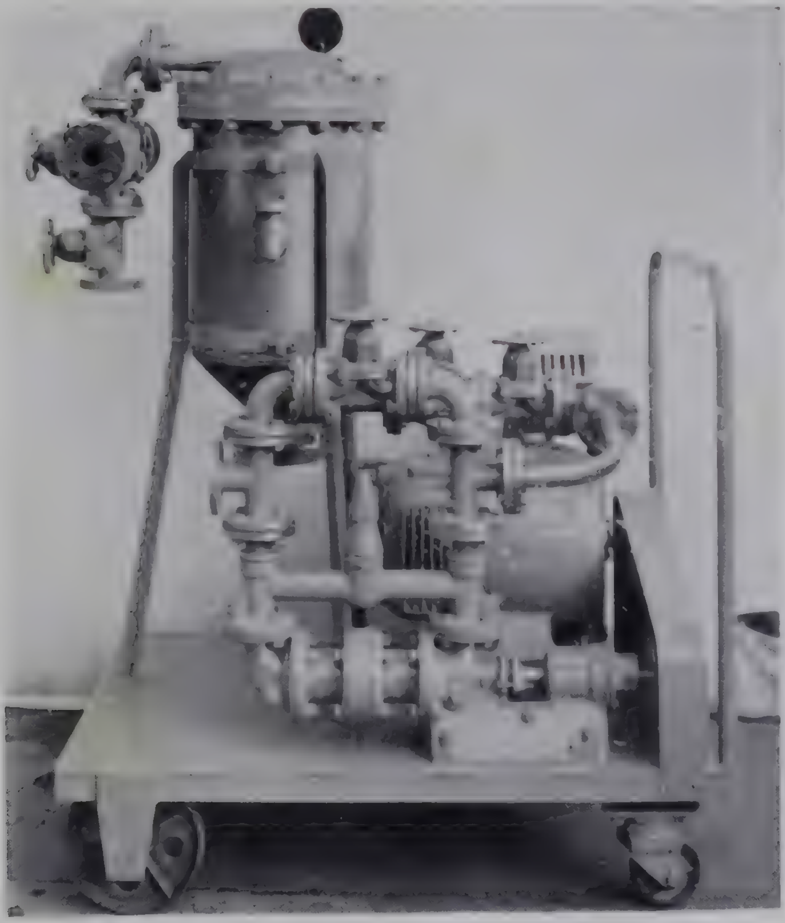
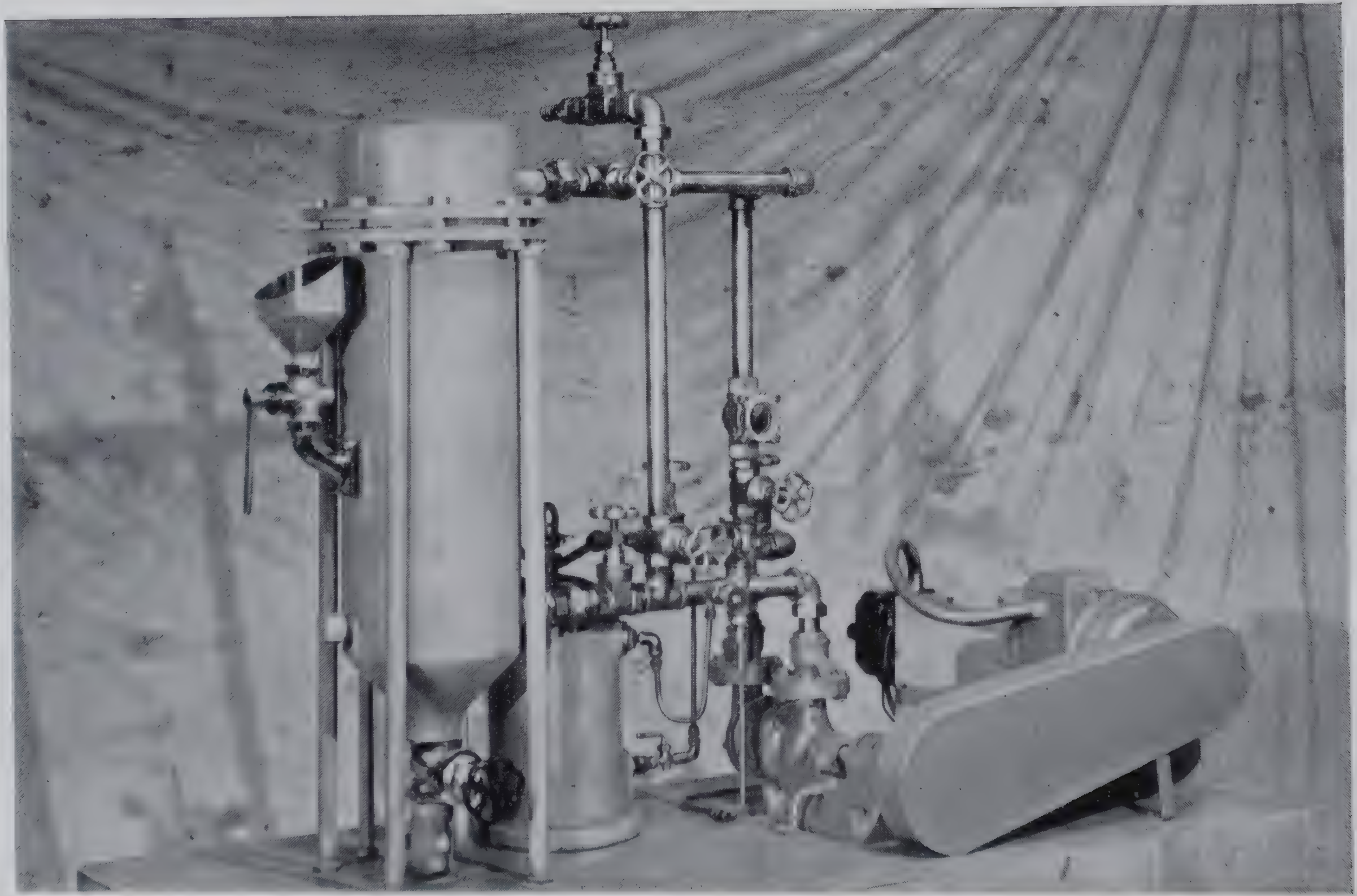


Fig. XLII. Metafilter for Cider Clarification



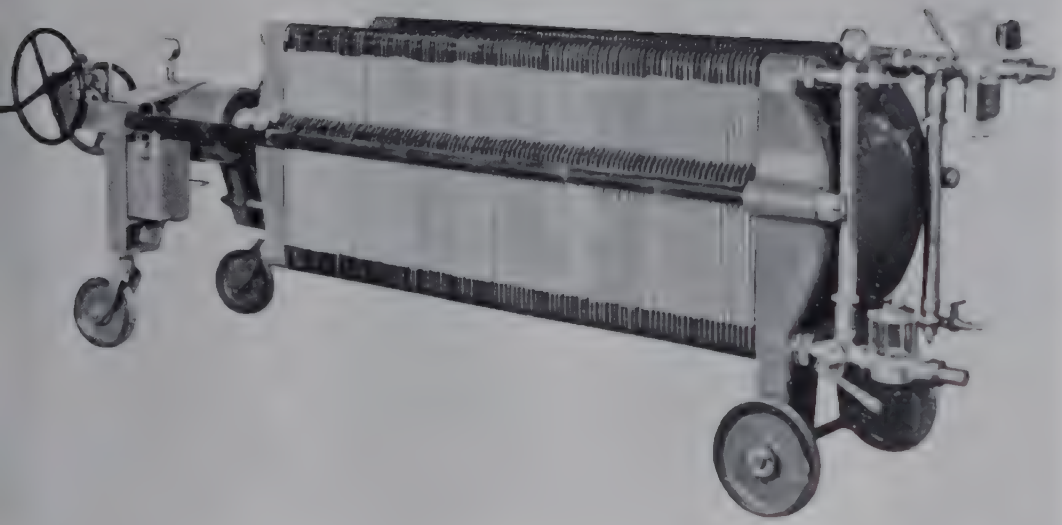


Fig. XLIV. Sheet Filter for Cider Clarification
British Filters Model)

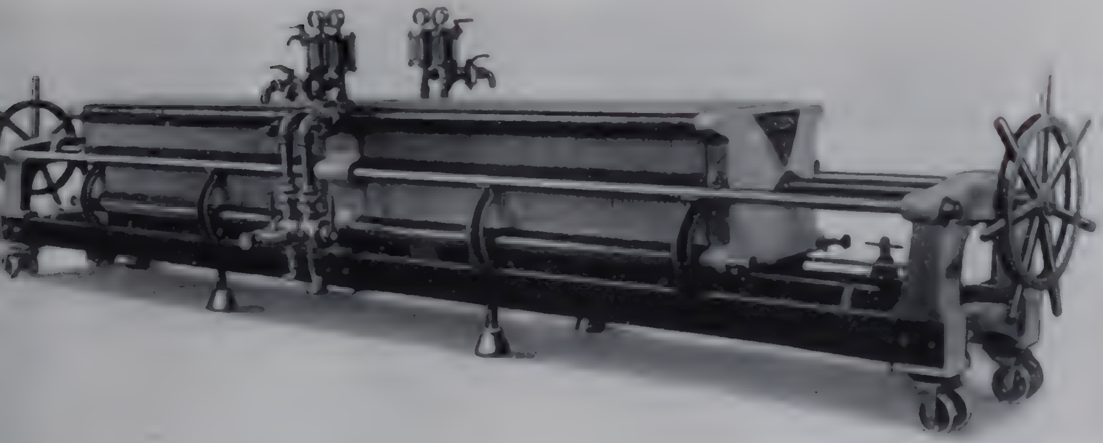


Fig. XLV. Carlson Sheet Filter 2 · 60 150 for Double Filtration

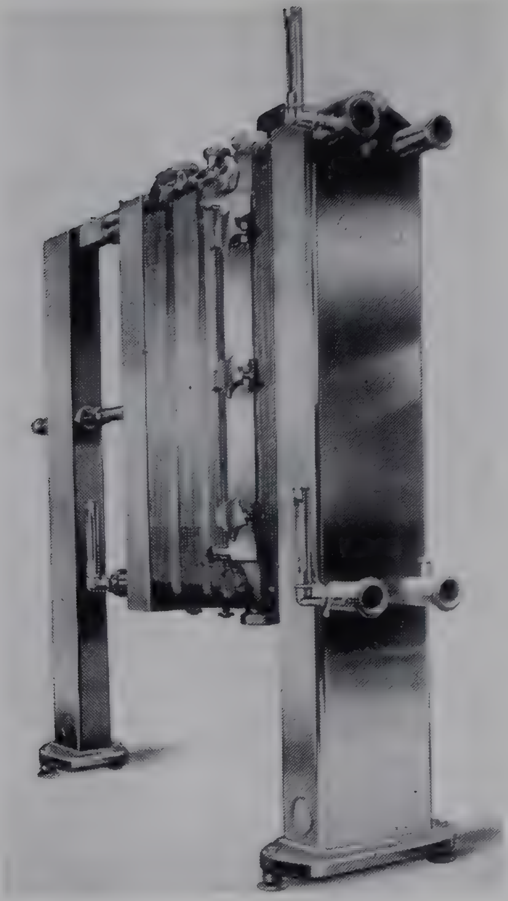


FIG. XLVI. A.P.V. Paraflow Heat Exchanger

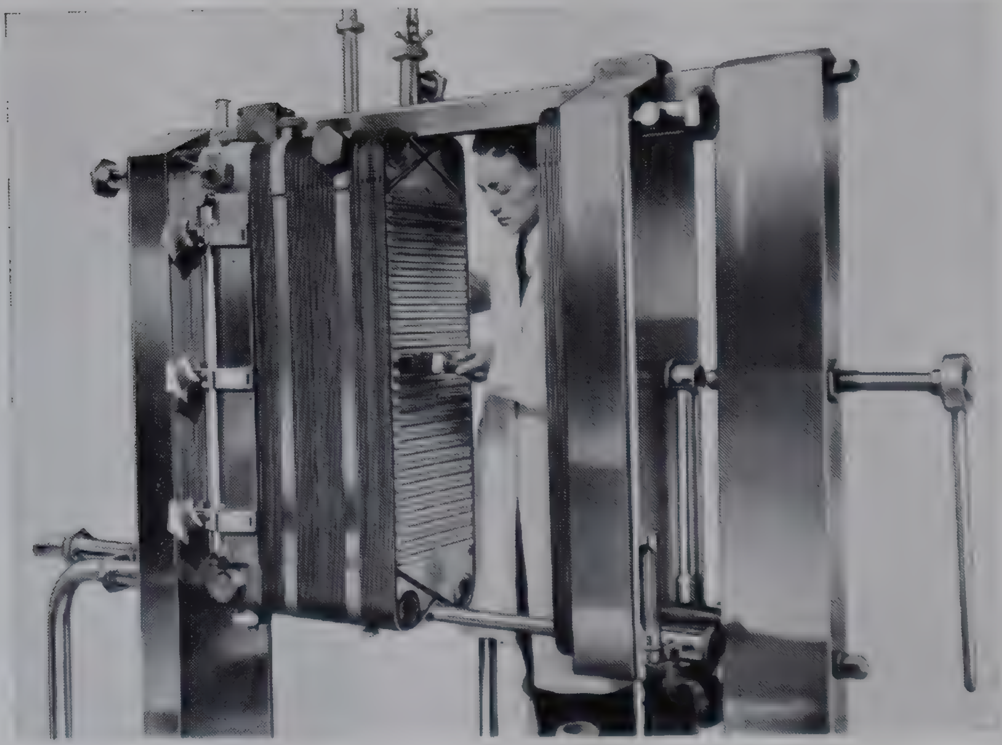


FIG. XLVII. A.P.V. Paraflow Heat Exchanger (open position) e excessive fermentation accompanied by a loss of clarity in ie cider, and the development of an excess pressure which may ventually break the bottle. Again, if the cider is filled in a oudy condition the bottled product cannot be expected to ear itself, and the precipitated solids will contribute to the olent evolution of gas on uncorking the bottle, with consequent loss of liquid, often to an excessive extent.

When filling bottles with cider, the head-space should be educed to a minimum by ensuring that the cider touches the ottom of the cork, leaving no bubble of air between the two.

If these precautions are observed, the restricted amount of east in the cider will produce a slow anaerobic fermentation in ottles laid on their side immediately after filling. Breakages ill seldom occur, and the bottles can be uncorked with ease nd without loss of the contents; the cider will be sparkling and considerable degree of standardisation in quality between all ie bottles of any one batch will be achieved.

The complete filling of bottles, as recommended above, is not dvisable in the case of ciders which will be subjected to exremes of temperature, for the expansion of the liquid will force ie contents between the cork and the neck of the bottle.

The bottling operation should be reserved, as for racking, or fine clear days of high barometric pressure.

To secure a sweet cider with considerable gas pressure, the roduct should be bottled at a gravity between 1·020-1·018. Normal sparkling conditions will be achieved by bottling at a ravity of 1·019-1·015; ciders to be consumed in a lightly sparking condition should be bottled at 1·013-1·010, whereas the east amount of gas evolution is associated with a bottling gravity f 1·008-1·005. These are not absolutely fixed figures, for the riginal gravity has some bearing on the problem, but they do t least give a general indication of the effect of bottling gravities on the ultimate condition of the cider.

In Germany, dry ciders are carbonated with carbon dioxide efore bottling. Such ciders, however, are usually fermented vith wine yeasts, and possess a vinous character more nearly esembling that of white wines than that of French ciders.

Sparkling ciders should be bottled in champagne bottles or n strong stone jars. The very slightly sparkling ciders can be afely stored in ordinary green glass bottles.

Corks should be carefully chosen for their high quality an
should be covered with boiling water before use. Immediatel
before they are inserted into the bottles, they should be soake
in eau-de-vie (distilled cider spirit); they should be wired i
and covered with paraffin wax if the condition of the cella
raises doubts as to the possible growth of moulds.

The filling and corking of bottles without any air space call
for the employment of special corking machines which ar
available for this purpose.

On the advice of Warcollier, certain makers desiring to obtai
perfectly clear ciders without deposit ferment their ciders i
bottles fitted with temporary conical corks and store these bo
tles in an inverted position for twelve to fourteen days. Th
deposit forms on the cork and is disgorged by the usual proces
The free space is filled with cider of the same type and th
bottles are then permanently corked. Complete freedom fro
further cloudiness or deposit can be ensured by this means.

Translator's Addenda

Pasteurisation

The preservation of cider in a sound condition during th
period between its clarification at the end of the fermentatio
process and its preparation for consumption is a matter of ve
great importance to the cider-maker. The use of pasteurisatio
whilst effecting an initial removal of all types of micro-orga
isms, is complicated, as mentioned by Warcollier, by the dif
culty of maintaining the pasteurised liquor in a sterile conditi
over relatively long periods. The process is not used to a
notable extent for this purpose, but it is appropriate to menti
certain improvements in continuous pasteurisation techniq
(1) that have occurred since the publication of *La Cidre*
These are mainly connected with the efficiency of the he
transfer in continuous pasteurisers as well as with the syste
now adopted to utilise the hot pasteurised product to heat t
incoming liquor. A machine which shows these various mode
improvements to advantage is the latest type of plate heat
changer of The A.P.V. Company Ltd. Figs. XLVI and XLV
illustrate the A.P.V. Paraflow Heat Exchanger, the seco

ure showing the plant in an open position to enable the con-
uction of the plates to be seen. The heating is achieved by
t water circulation with automatically controlled tempera-
re. Such machines, and those of other makers, can be used
erely to 'flash' the juice, i.e. to obtain sterility by raising the
uor to temperatures up to 90°C. for a period of less than one
inute, or alternatively a holding tube can be put in circuit to
able the product to be held at a given temperature for a con-
olled period of time. Such heat treatments over very short
nes are now referred to as H.T.S.T. (high-temperature-short-
me) methods. Although the principle of heat regeneration was
ferred to in 1928 by Warcollier, the modern improvements in
esign have increased efficiency in this respect to a remarkable
tent. A machine of a similar type to that mentioned and
lustrated above was tested in a London dairy and it was found
iat the milk was being heated from 10°C. to 62°C. solely by
ie heat in the milk already treated, thus showing a saving of
4% of the heat required for the pasteurisation process.

Although the pasteurisation developments have been men-
oned in the addenda to this Chapter, they have a more direct
earing on the production of unfermented apple juice, and will
e referred to again at the end of Chapter XVII.

Freezing

The freezing of cider with a view to its concentration and
onsequent improvement in keeping properties has been briefly
lluded to by Charley (2). Ciders were frozen once at −12°C.
nd after removal of ice, certain constituents were present in
oncentrations of approximately twice that of the original cider.
able XIV is reprinted in full from the Annual Report of the
gricultural and Horticultural Research Station, Long Ashton,
or 1935.

Table XIV.—Freezing Concentration of Cider

	Analysis of Cider				Analysis of Concentrate			
Cider	*Specific gravity*	*Acidity per cent*	*Tannin per cent*	*Alcohol per cent by weight*	*Specific gravity*	*Acidity per cent*	*Tannin per cent*	*Alcohol per cent by weight*
Knotted Kernel	1·008	0·37	0·23	5·25	1·016	0·61	0·40	8·55
Sweet Clusters	1·018	0·26	0·18	3·02	1·039	0·54	0·34	6·02
Woodbine	1·010	0·39	0·14	4·32	1·019	0·65	0·27	8·15

The alcohol content of the concentrates undoubtedly bestows ertain additional stability on the cider, and if suitable pro- cts are initially chosen remarkably fine beverages of a near- ueur type can be produced. However, the process is not likely become really important to the industry until the refrigera- n aspects have been perfected and cheapened. When this has een accomplished, the complete absence of any heat treatment hatever will be reflected in the natural, fresh aroma and avour of the products.

Refrigeration

The French cider industry can claim as one of its most utstanding contributions to recent cider-making technique e application of refrigeration, both to provide a slow, con- olled fermentation in the main processing, and to keep the ltered bulk cider in a safe condition during its storage life (3). uring the years 1930-1948, refrigeration was increasingly used large and medium sized factories for three purposes:

(i) To control the rate of fermentation of the keeved juice.

(ii) To maintain large bulks of medium sweet cider in a able condition.

(iii) To secure large quantities of juice in a completely un- ermented condition, to be blended with dry ciders later in the eason for the purpose of preparing naturally sweet ciders with- ut the addition of sugar.

For all these purposes, the cooling duty of the refrigerating achinery is a heavy one when considerable bulks of juice or ider are to be stored, and factories where this procedure is avoured have provided most impressive cooling installations. he reason for this extensive expenditure of capital is to be ound in the French view that the flavour of a medium sweet ider made by blending an unfermented juice (stored in the old) with a dry cider is superior to that of a dry cider sweetened vith sugar, or even to that of a cider made in the usual way by hecking the fermentation by one of the normal methods.

Storage of the unfermented juice may be undertaken in glass ined vats, often built into large assemblies totalling over half million gallons capacity, each vat being fitted with refriger- ting coils of sufficient cooling power to maintain the juice t 0°C. Such temperatures enable high quality ciders to be

made without the incorporation of any preservative at a
time.

The use of refrigeration for maintaining naturally con
tioned, bottled cider in good condition with special referen
to the prevention of excessive fermentation and unsightly
posits has been studied by Barker and Grove (4, 5, 6). Excer
from these three papers may be quoted to indicate their findi
on this subject. A range of bottled ciders was kept at 1°C. fr
May 1929 until January 1930, controls being provided at ro
temperature. 'The results of these tests clearly warranted
general conclusion that the storage of cider at 1°C. over a p
longed period causes a sufficient check to the various proces
associated with the ageing of ciders to retain the beverage
substantially the same condition as when it was placed in
cold store. . . By making use of low temperature storage,
cider-maker or bottler can keep his market supplied with
article of practically constant character over a period of at le
twelve months' (4).

'In practice, the scheme would work out as follows. If a cid
maker bottled a stock of cider during March or April, he wo
dispose of a certain amount during April, May and June.
about the middle of June the quantity wanted for disp
during the later summer and autumn months should be pla
in cold store for about eight weeks. . . The cost of cold stor
works out at about 30/- per ton per month (i.e. in 1930). Eig
dozen filled champagne pint bottles or forty-five dozen ch
pagne quart bottles weigh approximately 1 ton. The cost of
month's cold storage would consequently be 4½d. per dozen
pint bottles and 8d. for quart bottles.' (5).

'. . . it may be concluded that for ciders of the swee
medium sweet type, a period of from one to two months'
storage is effective in maintaining in good condition the na
ally conditioned bottled article for a considerably longer pe
than is possible by storage at ordinary cellar temperatures,
vided that the cider in question is in suitable condition
bottling in respect of capacity for residual fermentation. In
cases the actual time during the summer months at which
cold storage is applied appears to be immaterial. . . For ci
bottled prematurely and subject to excessive after-fermenta
in bottle, a limited period of cold storage treatment does

fice to keep this fermentation in adequate check for any use- period of time after removal from the store' (6).

Centrifugation

The past twenty years have seen the use of the centrifuge velop from merely an interesting idea to the present position which the machine, in one form or another, has become ndard equipment in the cider factory, and certainly one of e most valuable and essential instruments in the hands of a reful technician desirous of effecting a rigid control over his mentation processes.

The use of the centrifuge (outside France) was examined in 29-1930 by Barker and Grove at the Long Ashton Research ation (7, 8) and following their pioneer work, which resulted the machine being introduced into a number of factories, harley, from the same Station, made a study of the various oblems that had been encountered in the first few years of mmercial experience (9, 10). The attention of the cider in-ıstry was especially drawn to the centrifuge process as a means improving the quality of cider made from culinary apples, hich too often exhibited excessively high rates of fermentation ith inevitable deterioration of flavour and aroma. Juices from ılinary apples, when allowed to ferment with no form of con-ol, would often suffer a complete removal of sugar in three to ur days after the commencement of fermentation. Using such juice, Charley showed that by centrifuging through a Sharples ıpercentrifuge No. 6 machine at a speed of 80-100 gallons per our a practically complete cessation of fermentation could be fected by one treatment at a gravity of 1·024. Also, the fer-ıentation control increased in efficiency as the specific gravity the ciders for centrifuging became lower. The use of filters r such purposes was impracticable.

A further examination of the problem was made in 1934. he following points were made in the report on the season's ork.

(*a*) Effectiveness of fermentation control was correlated with ie total nitrogen content of the fresh juice (figures varying from ·018%-0·0053%). High nitrogen juices responded to a lesser egree than those with lower nitrogen percentages.

(*b*) Centrifugation of the fresh juice from high nitrogen apples had no effect on subsequent rate of fermentation, nor had thre further centrifugings at somewhat lower gravities.

(*c*) Some ciders could be maintained in a stable condition ove a period of 5-6 months by one single passage through a centr fuge at gravities as high as 1.040-1.047. In these cases, th nitrogen content must be very low (e.g. 0.0053% in one case

(*d*) The centrifugation appeared to act merely as a conven ent and efficient means of removing a crop of yeast, and th larger the crop the more effective was the result of the trea ment. The minimum fall in gravity before centrifuging could b economically applied was shown to be between 15 and 20 poin

(*e*) Centrifuging of ciders under optimum conditions remov up to 96% of the total nitrogen content of the fresh juice.

In 1939, Charley and Pickford (11) applied the results previous work to the bulk processing of cider in the factory the Research Station at Long Ashton. It was shown that t process was capable of application to considerable bulks of cid and that using wooden pipes and vats for storage, a very co siderable proportion of the cider produced in a season could maintained at a gravity above 1·020. Even better sugar rete tion was obtained by the addition of a single or double dose sulphur dioxide, added after the initial centrifuging treatme Some of these ciders, however, developed cider sickness at early date in the spring due to the complete absence of a secondary fermentation.

These experiments, in all of which a Sharples machine w used, indicate the value of the centrifuge as a means of ferme tation control. But it is not only for this purpose that the cid maker can utilise the effect of centrifuging. As a pre-clarif prior to filtration the machine is capable of extending the l of any given packing of the filter to a very considerable exte and its use on cloudy or thick ciders is of great economic sig ficance. A centrifuge may also be used with advantage for t utilisation of lees as the solid packs so tightly in the bowl th very large quantities can be dealt with without clearing machine. Centrifuges with bowls of large solids-holding capac have a special significance for this purpose (i.e. de Laval, Lar

The intense agitation occasioned in cider by its pass through the bowl of a centrifuge was considered to be a advantage insofar as it tended to aerate the cider. In very ases was the cider directly aerated by the machine, it being ather a case of the centrifugal action removing a proportion of e carbon dioxide dissolved in the cider as a result of yeast ction. However, any possibility of aeration is now precluded ither by the design of the machine or by the introduction of a tream of carbon dioxide into the bowl.

Figs. XLVIII and XLIX illustrate Sharples centrifuges. In he former, the two machines are installed in the factory of . N. Coate & Co. Ltd. of Nailsea, whilst the second photoraph is that of a special non-foam machine, which embodies different principle from that of the centrifuges supplied with arbon dioxide inlet. The bowl of the Sharples machine is exremely easy and quick to clean. Fig. L shows an Alfa-Laval otally enclosed centrifuge as used for cider work. Machines of his type have been tested at Long Ashton and have given every atisfaction. The output of cider can be very large, and although he speed of rotation (4,000 r.p.m.) is only one quarter that of he Sharples machine, the cider does not pass straight through he bowl but is taken through a devious route before being disharged. Fig. LI shows a Lang All-British centrifuge with a peed of 4,520 r.p.m. The internal diameter of the bowl is 21 nches, and it possesses a very large sediment space of 14 gallons apacity. This machine delivers cider with no foam and under pressure—a useful provision as no pump is required to take he cider to its place of storage.

Barker and Grove have published their observations on the elative flavour of centrifuged and filtered ciders (7). In general, the use of the centrifuge provided a soft, mellow cider, whereas the filtered cider from the same original blend was hard and, for a time at any rate, with a tendency for harshness. In some cases, moreover, ciders treated by the two methods were so dissimilar that it was difficult to believe that they had come from the same initial bulk of liquor.

Farm Bottling of Cider for Natural Conditioning

Barker and Grove (12) carried out a comprehensive examination of the conditions necessary for the satisfactory bottling of cider on the farm for subsequent natural conditioning. Aeration was shown to be a determining factor in the process. Extreme care in the storage of cider previous to bottling was necessary and it was found to be essential to study each prospective bottling blend and to apply to it such treatments as its previou history suggested as being desirable.

Those ciders that ferment at a relatively quick rate in cask should be bottled relatively later in the season. The month o April is, in general, the best month for bottling for natural conditioning, but exceptional ciders may with advantage be bottled in March or even May.

REFERENCES

Pasteurisation

(1) *The H.T.S.T. Plant*, J. R. Cuttell, Dairy Industries Ltd., London

Freezing Concentration of Cider

(2) Charley, V. L. S., *Ann. Rept. Long Ashton Res. Sta.*, 1935, p. 150.

Refrigeration

(3) Charley, V. L. S., *Ann. Rept. Long Ashton Res. Sta.*, 1937, p. 160.
(4) Barker B. T. P., and Grove, O., *ibid.*, 1929, p. 196.
(5) Grove, O., *ibid.*, 1930, p. 195.
(6) Grove, O., *ibid.*, 1931, p. 168.

Centrifugation

(7) Barker, B. T. P., and Grove, O., *Ann. Rept. Long Ashton Res. Sta.*, 1930, p. 19
(8) Grove, O., *ibid.*, 1931, p. 168.
(9) Charley, V. L. S., *ibid.*, 1933, p. 145.
(10) Charley, V. L. S., *ibid.*, 1938, p. 174.
(11) Charley, V. L. S., and Pickford, P. T. H., *ibid.*, 1940, p. 81.

Bottling of Cider on the Farm

(12) Barker, B. T. P., and Grove, O., *Ann. Rept. Long Ashton Res. Sta.*, 1924, p.

CHAPTER XIV

TRANSPORT OF CIDER

IDERS which have not completed their fermentation cannot be
ansported in hermetically sealed vessels without grave risk.
asks to be used for this purpose used to be fitted with vents
laced near the bungs and closed with straw or reed, and special
are was given to the casks where rail transport was concerned.
hese casks must be placed in the trucks with the bungs on top,
ıd the vents should be kept free from obstructions. The lack
such attention will lead to breakage, leakage and constant
isputes with the railway companies; certain of these in France
ave refused to settle claims on the grounds that the losses were
ue to fermentation—this being considered as 'vice propre'
.e. fermentation is regarded as an inherent possibility in cider,
nd the transporting agent will not, in such cases, accept res-
onsibility for any losses due to this cause).

The French Courts of Appeal have pronounced against such
contention. It has been laid down that fermentation should
ot constitute a 'vice propre' provided that the vents are fitted.
he Court of Cassation has made a similar ruling.

The large railway systems have undertaken a general study
f the problem to determine the best methods for transporting
ider which is still in a state of fermentation.

The State Railways have clarified the position to some extent
y the following measures:

(*a*) Special instructions have been issued to all its workpeople.

(*b*) The attention of all consignees of cider has been drawn
the advisability of using special automatic bungs.

(*c*) Sympathetic attention is given to all claims for loss of
ider during transport.

The French cider journal, *La Semaine du Cidre*, circulated a
uggestion that special bungs should be made compulsory to
void the loss of liquid which is inevitable when using vents
hich were packed with straw. It was further suggested that
pecial wagons should be used for the transport of cider.

Ciders that have shown a tendency to darken after a few hours' exposure to the air should be given special attention. The casks should be carefully sulphured before being filled through a pipe leading to the bottom of the cask, and it is ofte
useful to add ¾ oz. potassium metabisulphite per 100 gallon
of cider two days before the cider is despatched.

Automatic Bungs

The most effective form of closures for casks of cider ar
special bungs which prevent the loss of liquid whilst allowin
the escape of excess pressure of gas. Amongst such fitments ma
be cited the automatic metal valves (Poulpiquet pattern). Th
valve is held in position by a spring or rubber band, whic
enables it to lift when the pressure rises beyond a certain figur
thus permitting the escape of gas. This type of bung can b
covered with safety discs to prevent any loss of liquid throug
the bung during the journey. The automatic bung can only b
used when the bung hole is on top of the cask. Should the cas
be so placed that the bung is on the side or the bottom, th
pressure of the liquid in the cask is sufficient to operate th
valve with consequent loss of cider through the bung.

In 1924, a Joint Committee of organisations concerned wit
various phases of cider transport examined the Linder bun
which had previously given encouraging results. This applianc
was furnished with a rubber disc which formed a regulati
valve which could not be operated until the pressure develope
beyond a certain figure. This rubber seal simultaneously pr
vented the access of air to the cider. The float was protect
by a rubber washer which prevented the loss of liquid whi
might otherwise be caused by the normal movement of tran
port. This special bung was also provided with a fitment whi
contained lead shot, and the consignor could determine by e
amination of the state of the shot on receipt of the barr
whether the cask had been opened. The Linder bung did n
give complete satisfaction but the inventor later obtain
greatly improved results by including several judicious mo
fications into his appliance.

Barrels and Railway Containers

The different cider-making districts vary in their standa
type of container.

In Normandy, the 'pipe' is preferred. Its capacity is 130-180 gallons. The farmer's barrel, characteristic of Brittany, is almost cylindrical in shape. Hogsheads, universally employed in French cider districts, are very similar in shape and are standardised at a capacity of 132 gallons. Finally, a vessel known as a 'bordelaise' of 50 gallon capacity is also in use.

For transport of cider in wagons, wooden vessels are preferable to metal. Casks are less vulnerable to variations in temperature than metallic drums, the latter being unsuitable for use in summer.

The use of cylindrical steel casks coated internally with aluminium and hermetically closed has been recommended by Ray. One such vessel with a capacity of 220 gallons weighed 660 lb. when empty. Ray carried out his experiments on a 22 gallon cask. Storage of various ciders in such a vessel for several weeks did not affect their taste, colour, or appearance. When filling the barrel it was essential to leave an air space, the volume of which depended on the sweetness of the cider, but which approximated to 3-5% of the volume of the barrel. Violent movements of the barrel were said to have no effect on the cider or the barrel and no loss of liquid occurred. It is only when juice in full fermentation in warm weather has to be transported that it is necessary to use casks of a special form and strength to increase their resistance to increased internal pressure.

The ideal method of transporting cider would undoubtedly be to use artificial cooling. If the product could support the additional cost of transport in refrigerated wagons, or ship's holds, its consumption could be enormously expanded.

Translator's Addenda

Cider is still chiefly transported in bulk in wooden casks. The methods employed in France in very recent years, up to 1948, are given below:

(*a*) Sweet and medium sweet ciders are transported in wooden casks of 6 hectolitres (132 gallons) capacity. These casks are of particularly strong and sound construction and are provided, on their upper surface, with a very small hole for the removal of any carbon dioxide gas.

(*b*) When the distance of travel is less than about 150 miles it is becoming the practice to transport cider in road tanker with capacities between 1,000-3,000 gallons. The tankers mus be suitably lined, but in view of the economy of operation th industry evidently considers this method of transport as havin an important future.

(*c*) Transport of cider in tankers under pressure is no longe used to any appreciable extent, although certain operators ar investigating the possibility of utilising specially made high-pressure tanks for the reception and movement of juice impregnated with carbon dioxide according to the Böhi process (se notes following Chapter XVII).

In England, there has been an interesting development i recent years whereby carbonated cider is despatched in cask (30-60 gallons) to premises in large centres of population, wher it can be bottled without any further treatment. Such cask must be of very sound construction and are fitted with specia closures to facilitate the withdrawal of the cider without los of gas. Methods have also been devised for the transport o sparkling cider in smaller sized casks to public houses or hotel

CHAPTER XV

SPECIAL METHODS OF CIDER-MAKING

Treatment with Sulphur Dioxide

It has already been noticed that sulphur dioxide can enter into various processes in the cider factory (i.e. maceration, keeving, etc.) but there is a further way in which this preservative can be utilised.

In 1902, at the Pomological Congress at Amiens, Alliot suggested a process whereby the fresh juice of apples should be treated with 3 oz. potassium metabisulphite per 100 gallons and then inoculated with a pure yeast culture.

Warcollier has examined a similar method which has given excellent results (Warcollier, 'The rôle of sulphur dioxide in cider-making': *Bulletin Associat. franc. pomologique*, 2nd edition, 1913).

The juice of apples which has been pressed from pulp macerated and keeved in the presence of sulphur dioxide (the surface of the pulp being sprayed with a solution of sulphur dioxide which will contribute 3½ oz. sulphur dioxide per ton of pulp) will retain 3 oz. total sulphurous acid per 100 gallons. This is the maximum allowed by law. If this juice is keeved in the normal manner, it can then be allowed to ferment at a low temperature. This method ensures the provision of ciders that are clear, stable over long periods and free from acetification. It is especially suitable for fruit that has been badly harvested and is in a poor condition. Even better results are given when the fruit is clean and well washed with sterilised water before milling.

Method of Alliot and Gimel

The apples are washed in water containing 6-9 oz. calcium hypochlorite per 100 gallons for 15-20 minutes. After being drained, the fruit is milled and treated by a normal procedure. Ciders made in this way maintain their sweetness over a long period. Warcollier recommends the much wider adoption of this method but he prefers to rinse the apples free from the hypochlorite solution and then to follow his own method given in the previous paragraph.

Method of Chavastelon

There are three stages in this method, which was published in 1923.

(*a*) The fresh pulp is treated with ½-¾ oz. per 100 gallons of sulphur dioxide (or even more) and immediately after milling it is received into closed vessels furnished with a cock which will release any internal pressure to the outside atmosphere.

(*b*) The fermentation is regulated by aeration to a greate or lesser degree in order to activate the natural or selecte yeasts in the juice.

(*c*) The pulp is then pressed when the sugar has partly o entirely disappeared.

Chavastelon prefers to press the pulp after one or two month when some sugar still remains in the pulp. The final stage o the fermentation takes place out of contact with the pulp an permits a more rapid clarification after the aeration of the product, the finished cider having a little less pronounced taste o fruit, which is more pleasing to many palates.

Ciders destined for distillation can be fermented completel in contact with the pulp.

In 1923, Warcollier examined at Caen an almost exactl similar method. The milled pulp was placed in vessels closed b means of a hydraulic seal. The pulp was inoculated with a pur culture of yeasts, well mixed and allowed to ferment to dryness The cider so produced was recovered by pressing. These experiments indicated amongst other points that the reason fo the excessive bitterness of Normandy ciders produced by thi method was the inclusion in the pulp of the skin and stalks of th apples. The removal of these fruit tissues inevitably remove the bitter taste and provided acceptable beverages.

Rapid Fermentation

Situations sometimes arise when rapid fermentation of juic is desirable; for example, when stocks have run out at the en of August and must be speedily replenished from new season fruit in September. The cider-maker often finds a demand fo medium sweet cider from consumers in the large towns and thi an be satisfied by making cider from the first collections of uit in September. On other occasions, dry ciders for distillation re needed as a matter of urgency at the commencement of easons when fruit is cheap, so that the fermentation vessels an be used the maximum possible number of times during he season. The various procedures are outlined under three eadings.

(*a*) *Ciders destined for normal consumption.*—The keeving proess should be carried out in the normal fashion. The racking rocess can be effected without precautions to prevent access f air, and the clarified juice should be heated to 15°-18°C. and reated with 1½-3 oz./100 gallons of neutral ammonium phoshate. If the subsequent fermentation is slow, its acceleration hould not be procured by aeration of the whole bulk of the iquid, but by adding to it a starter as described in an earlier hapter.

By this means, the gravity should fall to 1·015-1·010 at the nd of 15 days. After one or two rackings or a filtration, the ider is ready for consumption.

Such ciders will generally be characterised by rather weak romas and will be less clear and satisfactory in their quality han those fermented at low temperatures. Their stability will e extremely limited.

The heating of the keeved juice to 15°-18°C. can be achieved y warming small portions of juice to 60°C. and mixing these nto the main bulk of the juice. Special heating apparatus is available for this purpose (i.e. the Besnard plant), whilst in large factories use can be made of waste steam for the same purpose.

(*b*) *Ciders for distillation.*—Warcollier has provided a special note on this subject (Societé nationale d'agriculture, March 1906).

Experiments were carried out on two vats with capacity of 132 gallons each and one vat of 1,320 gallons. For one of the smaller vessels, the procedure was as follows:

Two gallons of juice were inoculated with a pure cider yeast and treated with 2 g. of ammonium phosphate. The starter was placed in a very clean bucket, covered with a cloth and kept at 20°-25°C. After two days, when fermentation was active, the 2 gallons were added to 20 gallons of the same juice containing 3 oz. of ammonium phosphate. This liquor was also kept at

25°C. When the 22 gallons of mixture was in full fermentation the starter was added to the 132 gallon vat and a further 3 oz of ammonium phosphate were added; the juice was then maintained at 20°-25°C.

By this means a completely dry cider was obtained after 1 days. The other vat, treated in the same way but with a different yeast, fermented equally rapidly.

The ciders so made were distilled and gave excellent product which were softer than those produced from ciders that ha been fermenting for a period of 2½ months.

The rapid fermentation of the juice in the 1,320 gallon vesse was achieved in a similar manner. The juice was treated wit 3 oz./100 gallons of ammonium phosphate and was fermente at 27°C., having been heated by a Salvator heater capable c dealing with 330 gallons per hour. Unfortunately the vat wa not provided with any lagging and the temperature fell rapidl (1°C. per day until at the completion of fermentation the temperature was only 10°C.). Despite these conditions, howeve the fermentation only extended over twenty days. A distille spirit of good quality was produced from this cider. These experiments indicate that ciders for distillation can be fermented i ten to twenty days and that they produce excellent eaux-de-vi

German Ciders

Warcollier has given a detailed account of German cide ('Les cidres allemands', *Le Cidre et le Poiré*, Aug.-Sept.-Oct 1912), from which the following review is taken.

In Germany, the fruits preferred for cider-making have a acidity of 0·68-1·10% (as malic). These apples are 'dual purpos fruits for they can also be used in other ways—i.e. for cookin The juice is removed by two or three pressings with the incl sion of a little water in rebuilding the cheeses. The juice is thoroughly filtered and removed to fermentation rooms maintaine at 15°-18°C. by a special system of heating. Pure wine yea starters are used to secure rapid fermentation. No brown he is formed and racking is postponed until fermentation h ceased and the cider has spontaneously cleared itself. At a lat stage, when the cider has settled, a second racking is employ and the product is stored in vats at a temperature of 12° pending its preparation for sale.

German ciders are pale because the high acidity inhibits the oxidation of the tannins, apart from the fact that these juices are already deficient in tannin. The ciders possess a vinous taste, but they lack the bouquet and fruity character of French ciders. This is largely because the German fruit is milled before it reaches maturity and before the tissue has developed its full complement of aromatic compounds.

German ciders, however, possess two advantages. In the first place, the acidity acts as a preservative against disorders, chiefly acetification; and secondly, they maintain a perfect clarity due to the composition of the fruit employed.

The sharp character tends to disappear with the ageing of the cider. Bacteria decompose the malic acid, often to the extent of 60% of its original value, the acid being transformed into lactic acid and carbon dioxide. The responsible bacteria are active at 20°C.; they are inhibited by the presence of tannin, whilst 0·1-0·2% of sulphur dioxide completely prevents their development. German ciders are true apple wines and more closely resemble rather crude white wines than sweet and bitter-sweet ciders. If it is desired to contribute to the product an unmistakable flavour and appearance of white wine, pears should be mixed with the apples (1 part of pears to 2 parts of apples) before milling.

Ciders from French Sharp Apples

Warcollier has made a very complete study of this subject and has published his researches in a series of special communications ('Study of the variety of cider apples of the Aube district and their ciders, Pomological Congress of Rennes, *Bull. Assoc. française pomologique*, 1926; 'Contribution to the study of cider-making', *Bull. Assoc. française pomologique*, 1926).

The Tables on pages 212-215 set out the analyses of 19 single varieties of French cider apples, in which the acidities vary between 1·4-0·51% (as malic).

In general, these juices are very high in acid, low in pectins and extremely low in tannins. The following points have been elucidated by Warcollier's work.

Fermentation.—There is no coagulation and precipitation of the pectins, no brown head formation, and no keeving and subsequent racking is possible between top and bottom deposits.

TABLE XV.—ANALYSIS OF FRENCH SHARP APPLE JUICES

(results expressed as % w/v)

	Nez-de-Chat No. 1	*Vendue-Lévèque*	*De Bucey*	*De Glénon*	*De Vigne*	*Cuvet*	*Nez-de-Chat* No. 2	*Nez-plat*	*Petit-Blanc*	*A Ridlée*
Average weight of an apple	1·2 oz.	2·5 oz.	2·25 oz.	1·7 oz.	1·6 oz.	1·0 oz.	1·3 oz.	1·8 oz.	1·7 oz.	0·78 oz.
Gravity - - - - -	1·0585	1·0433	1·045	1·0675	1·063	1·042	1·052	1·057	1·050	1·0397
Reducing sugars - - -	8·0	8·93	8·66	6·58	10·61	7·76	8·0	9·12	8·81	7·53
Total sugars (as reducing sugars)	12·43	9·37	9·53	10·0	13·61	8·4	11·0	12·17	10·7	8·2
Glucose - - - - -	2·05	2·71	1·89	1·98	2·78	2·6	2·13	2·94	2·54	2·37
Laevulose - - - - -	5·95	6·22	6·77	5·6	7·83	5·16	5·87	6·18	6·27	5·16
Sucrose - - - - -	4·43	0·44	0·87	3·42	3·0	0·64	3·0	3·05	1·89	6·7
Glucose/Laevulose - -	0·35	0·43	0·27	0·17	0·35	0·50	0·36	0·47	0·40	0·45
Malic acid - - - - -	0·898	0·778	0·67	0·858	0·858	1·113	0·71	0·91	0·725	0·845
Tannin - - - - -	0·070	0·058	0·035	0·070	0·080	0·070	0·035	0·035	0·035	0·058
Pectic substances - -	0·4	0·2	0·27	0·76	0·63	Traces	0·46	0·57	0·44	Traces
Alcohol (potential) - -	5·94	4·40	4·56	4·80	6·50	4·00	5·29	5·77	5·13	3·92
Yield of juice (gallons/ton) -	100	115	113	85·5	86	119	101	105	101	123
Date of milling - - -	17 Dec.	17 Dec.	21 Dec.	21 Dec.	21 Dec.	28 Dec.	28 Dec.	28 Dec.	29 Dec.	29 Dec.

TABLE XVI.—ANALYSIS OF FRENCH SHARP APPLE JUICES
(results expressed as % w/v)

	Sauvageon Barré	*Cul-d'Oison*	*Petit-Locard*	*Pommate de Maraye*	*Locard-Barré*	*Châtaignier*	*Avrolles*	*Gros-Locard*	*Vérollot*	*Pommate de Boudon*
Average weight of an apple	2·95 oz.	2·75 oz.	2·9 oz.	2 oz.	3·3 oz.	2·9 oz.	2 oz.	3·5 oz.	3·75 oz.	1·65 oz.
Gravity - - - -	1·049	1·062	1·056	1·049	1·052	1·051	1·0508	1·051	1·050	1·050
Reducing sugars - - -	7·22	8·96	10·2	7·0	8·38	10·0	7·32	8·93	8·53	7·76
Total sugars (as reducing sugars)	10·6	13·3	12·4	10·1	11·4	11·0	11·0	11·0	10·8	10·4
Glucose - - - - -	1·6	2·44	7·66	1·4	2·07	2·68	1·75	2·33	2·29	1·77
Laevulose - - - -	5·62	6·52	2·54	5·6	6·31	7·32	5·57	6·6	6·23	5·99
Sucrose - - - -	3·38	4·34	2·2	3·1	3·02	1·0	3·68	2·07	2·28	2·64
Glucose/Laevulose - -	0·28	0·37	0·33	0·25	0·31	0·36	0·31	0·36	0·36	0·29
Malic acid - - - -	0·98	0·99	0·56	1·4	0·50	0·56	1·3	0·64	0·71	1·15
Tannin - - - -	0·117	0·188	0·152	0·1	0·070	0·058	0·035	0·058	0·058	0·047
Pectic substances - -	0·22	0·25	0·1	0·090	0·4	0·6	Traces	0·43	0·24	Traces
Alcohol (potential) - -	5·04	6·34	5·94	4·80	5·45	5·29	5·29	5·29	5·13	4·96
Yield of juice (gallons/ton) -	127	89	97·5	129	91	76	132	123	128	127
Date of milling - - -	2 Dec.	2 Dec.	2 Dec.	7 Dec.	11 Dec.	11 Dec.	14 Dec.	14 Dec.	14 Dec.	17 Dec.

TABLE XVII.—ANALYSIS OF CIDERS FROM FRENCH SHARP APPLE JUICES

(results expressed as % w/v)

	Nez-de-Chat No. 1	*Vendue-Lévèque*	*De Bucey*	*De Glénon*	*De Vigne*	*Cuvet*	*Nez-de-Chat* No. 2	*Nez-plat*	*Petit-Blanc*	*A Ridlée*
Gravity - - - - -	1·0095	1·002	1·0015	1·0102	1·0256	1·004	1·0035	1·0035	1·016	1·004
Dry extract at 100°C. - -	4·08	2·155	2·28	3·94	7·23	2·72	2·9	2·64	5·53	2·61
Reducing sugars - - -	1·6	0·15	0·29	1·55	4·8	0·27	0·51	0·4	3·1	0·62
Total sugars - - -	1·6	0·15	0·29	1·55	4·8	0·5	0·51	0·4	3·1	0·62
Sugar-free dry extract -	2·48	2·0	1·99	2·39	2·43	2·22	2·39	2·24	2·43	1·99
Alcohol (actual) - - -	4·98	4·15	4·33	3·75	3·83	3·59	4·74	5·46	3·28	3·40
Alcohol (potential) - -	0·72	—	0·10	0·72	0·22	0·17	0·24	0·17	1·45	0·24
Total alcohol - - -	5·71	4·15	4·41	4·49	6·1	3·75	4·98	5·62	4·74	3·63
Tannin - - - -	0·062	0·051	0·035	0·053	0·052	0·063	0·030	0·035	0·035	0·054
Total acidity (malic) - -	0·98	0·63	0·74	1·01	0·99	1·18	0·71	1·05	0·66	1·02
Volatile acidity (acetic) -	0·066	0·071	0·050	0·036	0·049	0·045	0·036	0·040	0·054	0·036
Fixed acidity (malic) - -	0·91	0·75	0·68	0·96	0·80	1·13	0·67	1·0	0·59	0·98
Ash - - - - - -	0·275	0·29	0·27	0·28	0·34	0·33	0·28	0·34	0·3	0·31

TABLE XVIII.—ANALYSIS OF CIDERS FROM FRENCH SHARP APPLE JUICES

(results expressed as % w/v)

	Sauvageon Barré	*Cul-d'Oison*	*Petit-Locard*	*Pommate de Maraye*	*Locard-Barré*	*Châtaignier*	*Avrolles*	*Gros-Locard*	*Vérollot*	*Pommate de Boudon*
Gravity - - - - -	1·001	1·0035	1·044	1·0105	1·0018	1·0015	1·005	1·000	1·0088	1·0035
Dry extract at 100°C. - -	2·28	2·37	10·94	3·82	2·395	2·17	3·05	2·06	4·08	2·09
Reducing sugars - - -	0·17	0·23	8·53	0·45	0·2	0·2	0·81	0·15	1·66	0·3
Total sugars - - -	0·17	0·23	8·53	1·5	0·2	0·2	0·81	0·15	1·66	0·3
Sugar-free dry extract - -	2·11	2·14	2·41	2·32	2·19	1·97	2·24	1·91	2·42	2·29
Alcohol (actual) - - -	4·98	6·02	1·53	3·96	4·89	4·98	4·74	5·17	4·15	4·64
Alcohol (potential) - -	Nil	0·10	4·07	0·72	0·10	0·10	0·32	Nil	0·72	0·10
Total alcohol - - -	4·98	6·1	5·62	4·69	4·98	5·05	5·05	5·17	4·9	4·74
Tannin - - - -	0·111	0·170	0·146	0·1	0·053	0·051	0·030	0·058	0·053	0·044
Total acidity (malic) - -	1·02	0·99	0·71	1·27	0·61	0·47	1·35	0·67	0·80	1·15
Volatile acidity (acetic) -	0·036	0·061	0·045	0·045	0·036	0·045	0·040	0·044	0·057	0·041
Fixed acidity (malic) - -	0·98	0·92	0·66	1·22	0·57	0·42	1·31	0·62	0·74	1·10
Ash - - - - -	0·195	0·3	0·295	0·31	0·28	0·37	0·29	0·215	0·235	0·37

No pectin flocks are formed during fermentation, and the ciders remain cloudy throughout, although they clarify themselves at the end of the yeast action. The varieties which cause most trouble from cloudiness are *à Ridlée*, *de Bucey*, *Sauvageon Barré*. A pulp filter can be used for their clarification, whilst gelatin fining with 1½ oz./100 gallons has given very good results. Samples of these ciders which have neither been filtered nor fined will clear themselves in time without any special treatment.

Rate of fermentation.—When the ciders clarify themselves during the fermentation, the product obtained by racking at this stage will subsequently ferment very slowly.

Six months after the pressing of the juice from the apple, the *Petit-Locard* cider still showed a gravity of 1·044 and retained 8·5% of sugar. Amongst other ciders with very slow rates of fermentation may be cited *de Vigne*, 1·025; *Petit-Blanc*, 1·016 *de Glénon*, 1·010; *Pommate de Maraye*, 1·010; *Nez-de-Chat* No. 1 1·0095; all the gravities being taken at the same period as fo the *Petit-Locard* sample.

Type of fermentation.—All fermentations were carried out by the natural organisms on the apples. No disorders arose in the ciders and the volatile acidities were always very low.

Nature of the yeasts.—The yeasts are mixtures of round and elliptical cells, apiculate types and elongated forms of wild yeasts. It is always found that in areas where cider orchards are less numerous and other fruits are grown to a considerable extent, the yeasts on the surface of the apples have no such simi larity in form as is the case in Normandy, for example, where the acceptable yeasts are well acclimatised to the condition and give the best products of fermentation.

The discovery of certain ciders with a vinous rather tha cider character was not unexpected.

Colour.—All the ciders were either pale or possessed no charac teristic colour at all. The deepest shades of colour were show by *Petit-Locard*, *Locard-Barré*, *Vérollot*, *Nez-de-Chat*, *de Glénon*. A the other end of the scale was *Boudon* cider, which was, in fac colourless.

Taste.—All the pale ciders with high acidity possessed a vi ous taste; they were suggestive of blends of white wine wit cider or perry. The best ciders seemed to be *Nez-de-Chat*, *Ne plat*, *de Vigne*, *Gros-Locard*, *Petit-Locard*, *Chatâignier*.

If the acidity is reduced, the value of some of these sharp iders is considerably enhanced. The neutralisation of the malic cid can be effected by adding 1-2 lb. pure precipitated calcium arbonate per 100 gallons of juice. The chalk should be added o the fresh juice and not to the finished cider.

It should be remembered in this connexion that ciders with very high acidities will lose some of their sharpness as they mature. The lactic acid so formed is not detectable by the palate as a disagreeable flavour. Ciders that are undrinkable in their first year (acidities of 0·82-1·23%), lose sufficient acidity in the succeeding one or two years to become quite potable. The detailed examination of this problem has been undertaken by Warcollier and the results published in 1917 (*Le Cidre et le Poiré*. June, August and September, 1917).

In conclusion, it can be said that there is in France only a limited demand for these sharper types of ciders. They are suitable for sale in certain areas on the borders of the cider and wine districts where these two beverages are equally consumed and where the people prefer pale vinous ciders to the normal type of bittersweet product.

To preserve the organoleptic quality of these ciders, they should be stored saturated with carbon dioxide. They store well in bottles with natural or artificial carbonation, and they are most suitable for blending with more bitter ciders for the application of the champagne cider process.

Sharp Cider Processing

The following processes are recommended for apples with acidities between 0·55-1·37%.

(*a*) Mill the fruit.

(*b*) Macerate the pulp for a few hours to soften the tissue.

(*c*) Apply pressure slowly.

(*d*) Immediately filter the juice to slow down the rate of fermentation.

(*e*) Induce a slow fermentation, without keeving or the formation of a brown head.

(*f*) Filter the cider at a gravity of 1·030, preventing access of air.

(*g*) Storage in special cylindrical vats tapering towards the top.

CHAPTER XVI

PRODUCTION OF SWEET CIDER

The increasing demand for sweet cider, especially from the large centres of population, has forced the cider industry to seek methods whereby it can supply a sweet product throughout the year. Its efforts in this direction have been greatly assisted by the research work undertaken by the Research Station in Cider-Making at Caen. Various methods have been perfected there which avoid the addition of any sugar to the cider.

In actual fact, two types of sweet cider are available:

(*a*) Naturally sweet ciders in which a proportion of the sugar of the juice remains unfermented.

(*b*) Ciders produced by sweetening a completely dry cider with an apple juice which has been maintained in an unfermented condition.

Naturally Sweet Ciders

These ciders retain to a remarkable degree the natural fruity character of the apples. The fruit character, which is derived from the apples themselves, is not affected by the yeasts, but, conversely, completely fermented ciders which are sweetened with added cane or beet sugar have lost practically all their characteristic flavour and aroma due to the action of the yeasts during the necessarily extended period of fermentation. Naturally sweet ciders are particularly suitable for bottling because of their aroma and distinctive flavour. The highly praised bouquets of ciders made by the use of special yeasts can in no way compare with the superior character of ciders which retain some of their natural sweetness.

Sweet ciders fall into three classes:

(i) Ciders which retain their sweetness without the use o special treatments.

(ii) Ciders produced in large factories by the employmen of special processes.

(iii) Naturally sweet, single variety ciders.

Juice from the variety *Mettais*, which has been exhaustively studied by Warcollier, can be cited as an example of a protracted fermentation producing a naturally sweet cider.

The *Mettais* apple (syn. *Sauvageon Adrienne*) was developed from a seed grown thirty years ago by M. Mettais, a farmer at Amfréville-la-Campagne (Eure). The tree grows very tall and is a good cropper. The fruit is exceedingly fine, regular and flat in shape, and orange-coloured streaked with red.

In 1913, the French Pomological Association awarded this variety the first prize in the class for casks of single variety cider and a first prize for sparkling bottled cider. In October 1920, at a Pomological Exhibition at Neubourg, Warcollier noted both cask and bottled ciders made from this variety and gave the highest commendation to both products. Its sweet, mellow nature softened the agreeable astringency, and its delicate aroma and attractive colour combined to provide a product of the highest quality.

Warcollier commenced his study of this variety in 1920. The table (p. 220) gives the analyses of the juice at various stages of fermentation. The very slow fermentation can be easily appreciated from the figures, for the gravity after six months had not fallen below 1·032, and the residual sugar was still as high as 6%.

The chief points of interest in the juice from the *Mettais* variety can be described as follows:

(*a*) High original total sugar content (14·9%) capable of providing 6·42% by weight of alcohol at the conclusion of fermentation.

(*b*) High sucrose content (26% of the total sugar).

(*c*) High tannin content (0·34%) providing a pronounced, but pleasant, astringency.

(*d*) Low acidity (0·16%) causing a tendency for the cider to darken in contact with air.

(*e*) Very low nitrogen content (0·0032%) compared with the average of 0·01% for apple juice and 0·04% for grape juice.

During fermentation, the juice clears very slowly and the first racking usually takes place twenty days after it is pressed from the fruit. Subsequent fermentation proceeds so slowly that it is not complete at the end of one year.

TABLE XIX.—ANALYSES OF CIDERS FROM FRENCH SHARP VARIETY METTAIS (results expressed as % w/v)

	Pure Juice	Cider			
		18th Dec. 1920	*27th May* 1921	*29th July* 1921	*20th Sept.* 1921
Specific gravity	1·067	1·061	1·046	1·040	1·032
Reducing sugars (as glucose)	10·72	9·40	8·76	7·60	6·02
Sucrose	3·95	3·08	0·54	0·14	0·00
Total sugars (as glucose)	14·88	12·65	9·33	7·75	6·02
Glucose	1·59	1·50	1·46	0·80	0·35
Laevulose	9·13	7·90	7·30	6·80	5·67
Sucrose / Total sugars	0·17	0·19	0·20	0·11	0·06
Glucose / Laevulose	0·26	0·24	0·05	0·01	
Total acidity (as malic acid)	0·21	0·27	0·38	0·41	0·42
Volatile acidity	—	0·055	0·068	0·068	0·082
Tannin	0·34	0·32	0·32	0·31	0·31
Pectic substances	0·61	0·55	0·53	0·51	0·50
Mineral substances	0·392	0·38	0·37	0·36	0·36
Nitrogen	0·0032	—	—	—	—
Alcohol (actual)	—	—	—	—	3·92
Potential alcohol	6·99	—	—	—	2·88
Total alcohol	—	—	—	—	6·83
Sugar-free dry extract	—	—	—	—	2·85

This excessively slow fermentation can be ascribed to various factors.

(i) *Viscous condition of clarified juice.*—Yeasts develop only with difficulty in a naturally clarified juice if it retains a relatively high viscosity. The juice only retains traces of oxygen, which is immediately absorbed by the tannins through oxidase activity. The yeast consequently cannot increase its weight on account of the lack of oxygen and nitrogen in the medium; again, it cannot perform its fermentative function except under difficulties because the zymase is inhibited by the tannins in the juice.

(ii) *Low nitrogen content.*—Within certain limits, the rate of fermentation of apple juice is directly proportional to the nitrogen content. In 1904, Warcollier (*Bulletin de l'Association français* *omologique*) showed that a naturally sweet cider could be pro-uced by starving the juice of nitrogen.

In 1908, Professor Barker (*Jnl. Ag. Sci.*, Vol. 3, Part 1, p. 1), nd in 1919 Otto Grove (*Ann. Rept. Long Ashton Res. Sta.*, 1919, . 20) examined the same problem and came to the same con-lusion as has been stated above. Grove concluded that the ninimum amount of nitrogen needed for complete fermen-ation was greater than 0·01%.

In the case of the *Mettais* cider, however, the low nitrogen ontent cannot completely explain the slowness of the fermen-ation. The addition of 0·02% ammonium phosphate did not ncrease the rate of fermentation; but it was noted that the uice, which had first been fined with gelatin to remove its annin and then treated with ammonium phosphate, fermented so quickly that the cider became dry after a few days. Warcollier considered it proven that the tannins in the juice retarded the yeast action.

(iii) *Action of tannin on yeasts.*—Rosenstiehl in 1900 published his work on the multiplication of yeast without fermentation in the presence of a limited quantity of air, and in 1902 a note appeared from the same worker on the action of tannins and colouring materials on the activity of yeasts. The first communication showed that cider yeast which had been grown in sterile apple juice and then placed on gelose or gelatin was incapable, after two consecutive sub-culturings on the same medium, of directly fermenting apple juice. The yeast colonies taken from the gelatin are not able to ferment a juice; the cells fall to the bottom of the liquor, no gas is evolved, but the yeast deposit increases in weight. The yeast has retained its power of multiplication, but the cells are smaller than the normal size. Finally, when sufficient gelatin is added to the juice to precipitate all materials that can be removed from solution, fermentation immediately ensues, indicating that the tannins of the juice have suppressed the fermentative faculty of the yeast whilst its reproductive power was retained.

The work of Rosenstiehl in 1902 described the inhibiting action of tannins on yeasts as being connected with the process of adsorption—a type of dyeing process. The composition of the living organism is modified by its combination with a material provided by the fermenting medium; the organism is not killed but its physiological functions are fundamentally affected. The fermentative power is reduced and ultimately completely suppressed, the reproductive capacity of the yeast remaining for a longer period.

These considerations can be applied to the *Mettais* cider to explain its protracted fermentation.

Warcollier has isolated from this cider a bottom yeast, with practically spherical cells of 4-6μ diameter. This yeast can ferment sucrose and forms a compact deposit; it is not affected by commercial tannins, for its action is not retarded by addition of 1 % oak gall tannin to a sugar broth in which the yeast was developing.

The same yeast, however, placed in colourless *Mettais* juice (with a very slight addition of sulphur dioxide) and enriched with nitrogen, will cause it to ferment. Hence, apple tannins, if they are not oxidised by the natural oxidase system do not retard yeast growth. This point had not been noted by Rosenstiehl.

The apple variety Mettais provides, at the precise moment of milling, a colourless juice which can be prevented from darkening by maintaining it in an atmosphere of carbon dioxide. At the moment that the protection provided by the carbon dioxide is removed, the juice becomes coloured and the yeast action is retarded; the yeast enzymes are inhibited, particularly the zymase. Consequently, the fermentation becomes slower, a has already been pointed out in the consideration of the fermentation of Mettais juice by the yeast natural to that variety

On every occasion that the oxidised form of tannin in Mettai juice has been precipitated by gelatin, Warcollier has observe that fermentation developed spontaneously. To a series of flask each containing 100 ccs. of juice were added increasing dose of 5 % gelatin solution. In every sample where the addition gelatin was sufficient to precipitate the tannins, fermentatio became noticeable immediately. It is not correct to attribut the fermentation to the addition of gelatin, for according t Rosenstiehl this substance does not provide any assimilabl nitrogen.

One other point of importance needs to be emphasised. Th oxidised form of tannin in an apple juice can combine with th natural albuminoids, forming insoluble compounds whose r oval thus further impoverishes the juice in nitrogen. Again, e presence of tannin in an oxidised form encourages the forxation of insoluble compounds which in the course of their recipitation, flocculation and removal from the juice, effect a larification and a virtual microbiological purification of the edium.

The considerations of the preceding paragraphs show that the lowness of fermentation in *Mettais* juice is due both to its lack of itrogen and to its property of rapid darkening on contact with ir, which darkening is a criterion of the formation and presence f appreciable amounts of tannin in an oxidised form.

Warcollier has noted on several occasions that highly coloured iders often ferment very slowly. Cider made from the *Gagnevin* ariety of apple, from the Bayeux area, is a case in point. The ider is very highly coloured and remains sweet over a long eriod. For this reason, Warcollier is inclined to suggest that uch raw materials should be particularly appropriate for the abrication of sweet ciders, provided that their processing is arried out in a rational manner, and that the production of a ertain amount of oxidised tannin is ensured in the course of a carefully conducted maceration in contact with air.

Naturally sweet ciders are not as rare as might be imagined. Many types of vintage ciders can be included in this category. Such ciders possess a prominent fruit character, very much more attractive than that of completely fermented beverages.

In the area of the Bessin, ciders made from the variety *Gagnevin* harvested from certain localities remain sweet for a long period. In the Vallée d'Auge, similarly slow fermentations occur with varieties such as *Domaine*, *Joly rouge*, *Cimitière*, etc., when these varieties are grown on certain soils. Thus, it is necessary to add the influence of the soil to the other conditions essential for the production of naturally sweet ciders (i.e. thorough spontaneous clarification, low nitrogen content and high total tannin and oxidised tannin figures). It has previously been shown that the success of keeving is dependent on the general character of the juice and that this character varies with the soil on which the trees are grown. Thus, the nature of the soil is of twofold importance in obtaining naturally sweet ciders.

In the Vallée d'Auge region, between Pont l'Évêque and Lisieux, the varieties *Joly rouge* and *Cimitière* milled at the same time give ciders which vary in many respects according to the exact locality in which the fruit is grown. Soils of marl or limestone provide ciders which clarify very poorly during keeving. The ciders remain cloudy, they ferment quickly to dryness, and their keeping qualities are deficient. Clay soils are associated with ciders that clarify relatively well, but do not retain their sweetness. Sandy or pebbly formations conduce to good clarification, the natural sweetness is retained over a period of one year, and the gravity of the ciders remains about 1·025.

For this reason, when a certain variety is referred to as providing naturally sweet ciders, the type of soil should always be mentioned. The variety Mettais, if grown on soils which are widely different from those of its natural habitat, will yield juices that clarify only with difficulty and which do not posses the useful characteristics for which this variety is usually known

Many writers have noted the influence of soil on the ultimate character of these ciders. Julien Le Paulmier in 1588 considered that the soil conditions were more important for cider than fo wines, thus: 'The Costentin district gives the very best results The Vallée d'Auge produces strong and full bodied ciders, bu these are generally harsh, crude and clarify badly. The distric around Caux contributes an earthy taste to the cider althoug this effect is less prominent on clay soils.'

More recently, Caumont has reported that 'the quality o ciders produced from different soils shows considerable differences which are obvious to consumers who have the opportunit to compare the products of various districts'. Caumont als refers to the advantage of soils which contain siliceous or quar fragments.

Warcollier has also noted that excellent ciders are alway produced from fruit grown on soils derived from schists an quartzites; for example, soil from certain communes in th canton of Bricquebec (Manche).

In the Calvados district of Trois-Monts, on the border Orne and a little to the north of Thury-Harcourt, two ma geological formations are found: oolitic limestone, more or le decalcified, and the schists (St. Lo slates or blue schists). Th apple plantations are associated with limestones or calcareo clay soils on the one hand, and with shallow schist formatio on the other. The ciders produced from the latter type of s

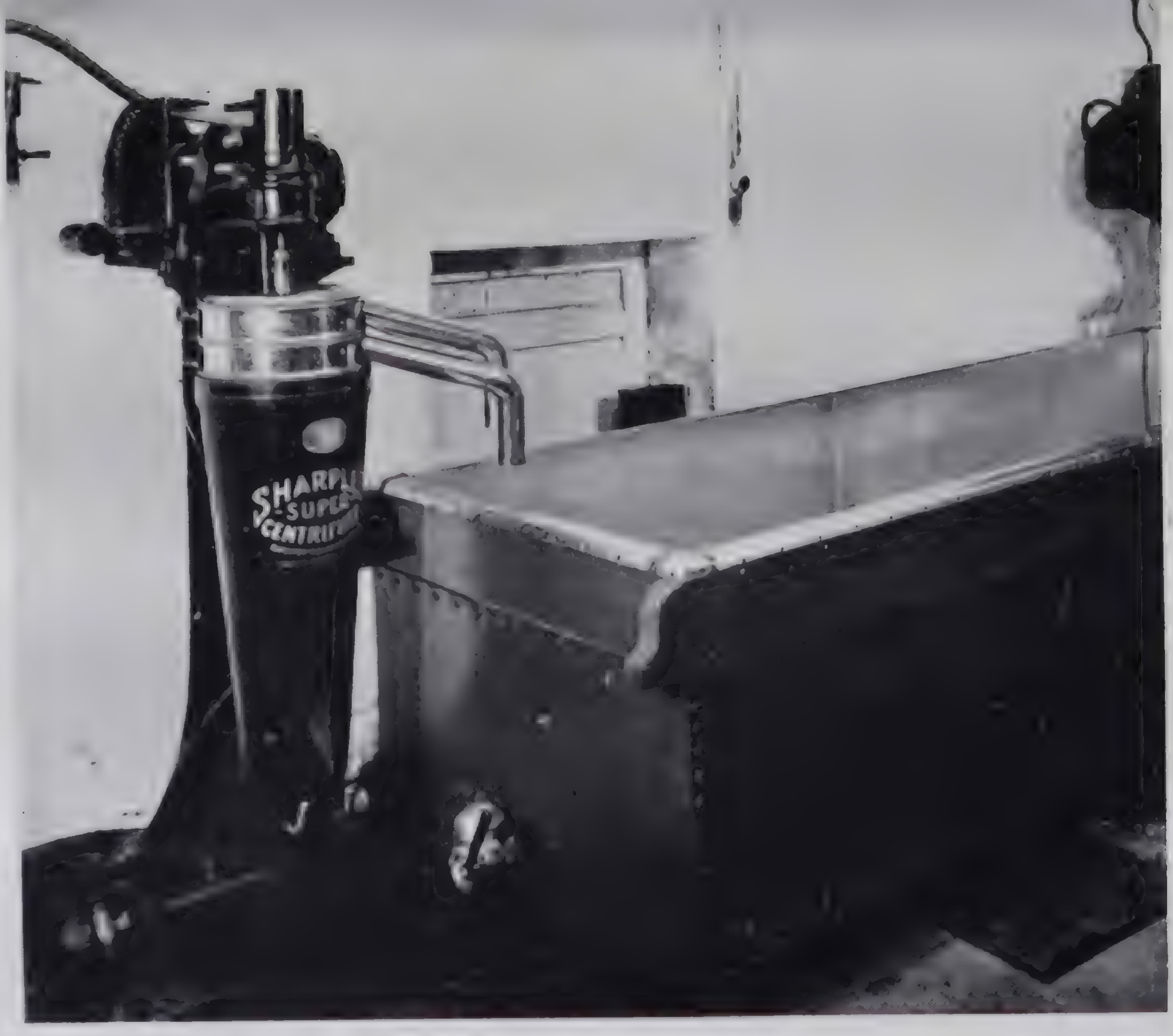

SHARPLES
SUPER
CENTRIFUGE

Fig. XLVIII. Sharples Super Centrifuge for Cider Clarification

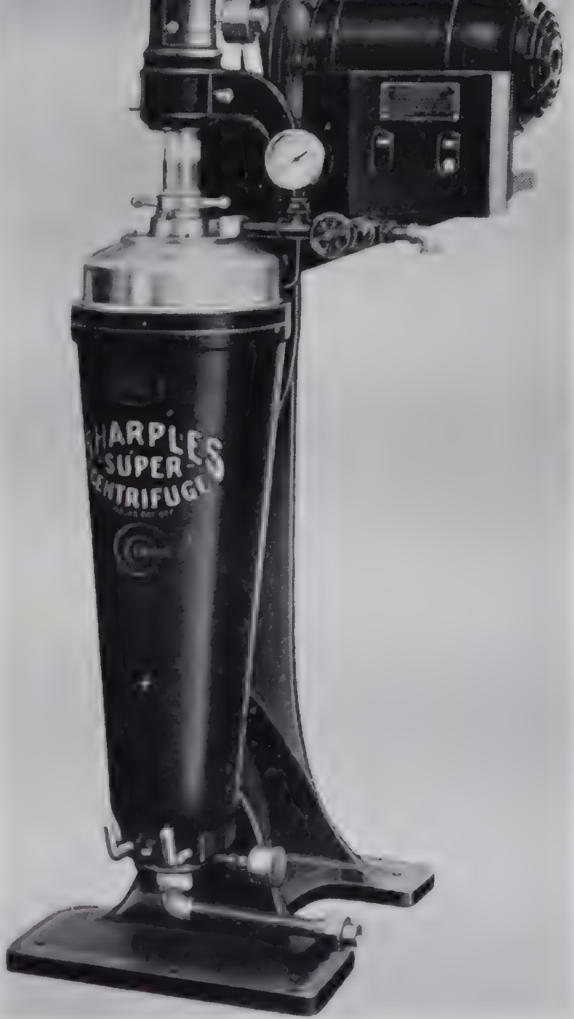

SHARPLES
SUPER
CENTRIFUGE

Fig. XLIX. Sharples 'No-foam' Centrifuge for Cider

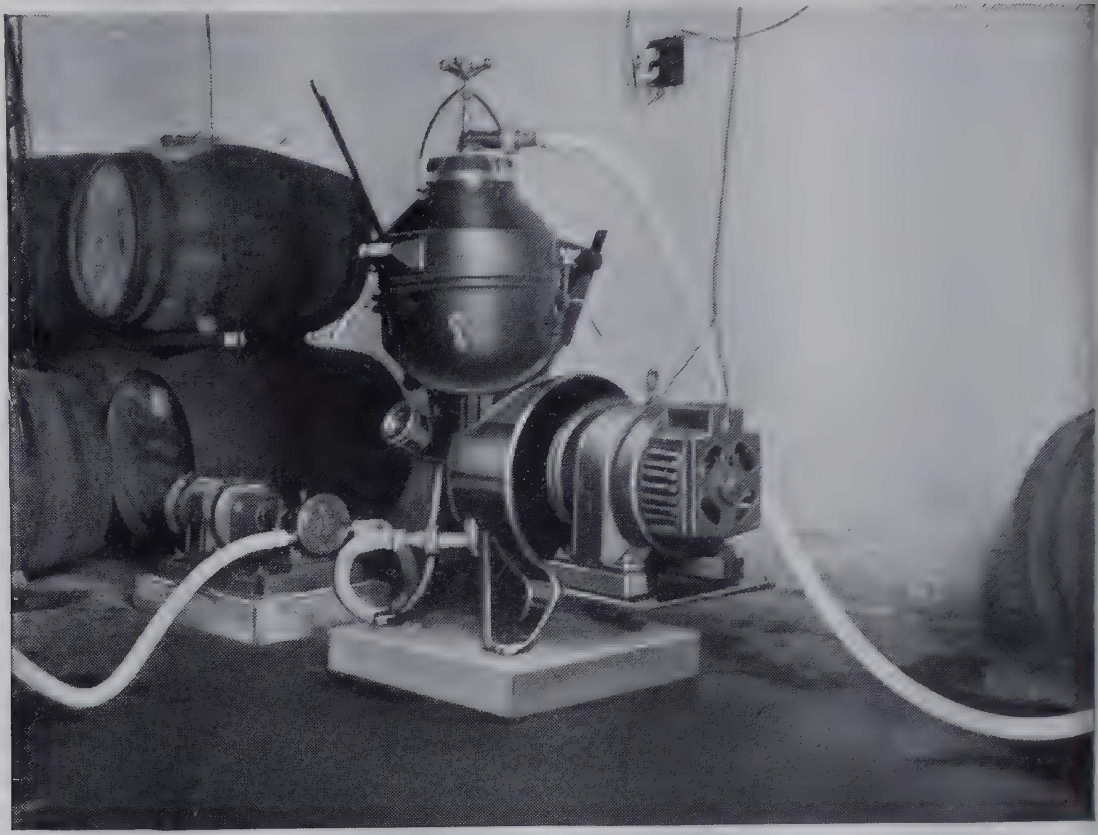


FIG. L. Alfa-Laval Centrifug

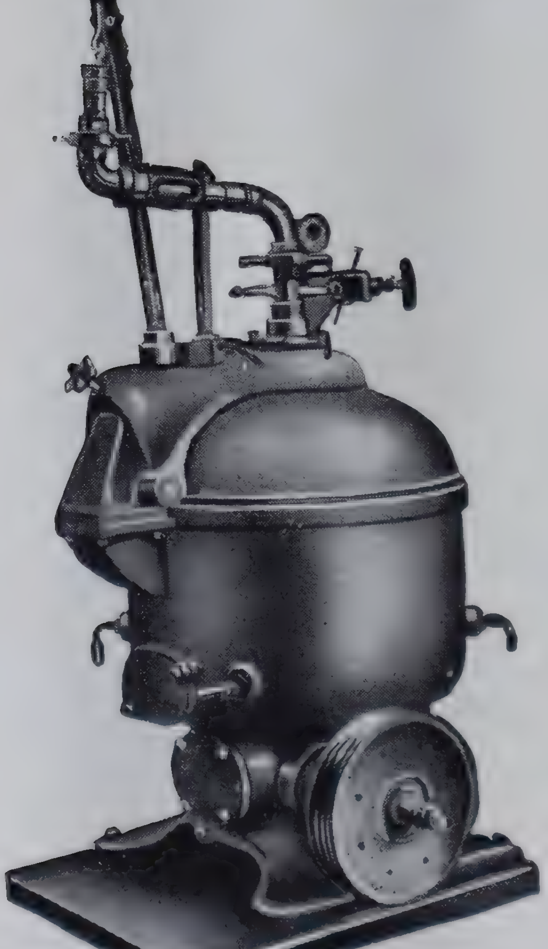


FIG. LI. Lang All-British Centrifu

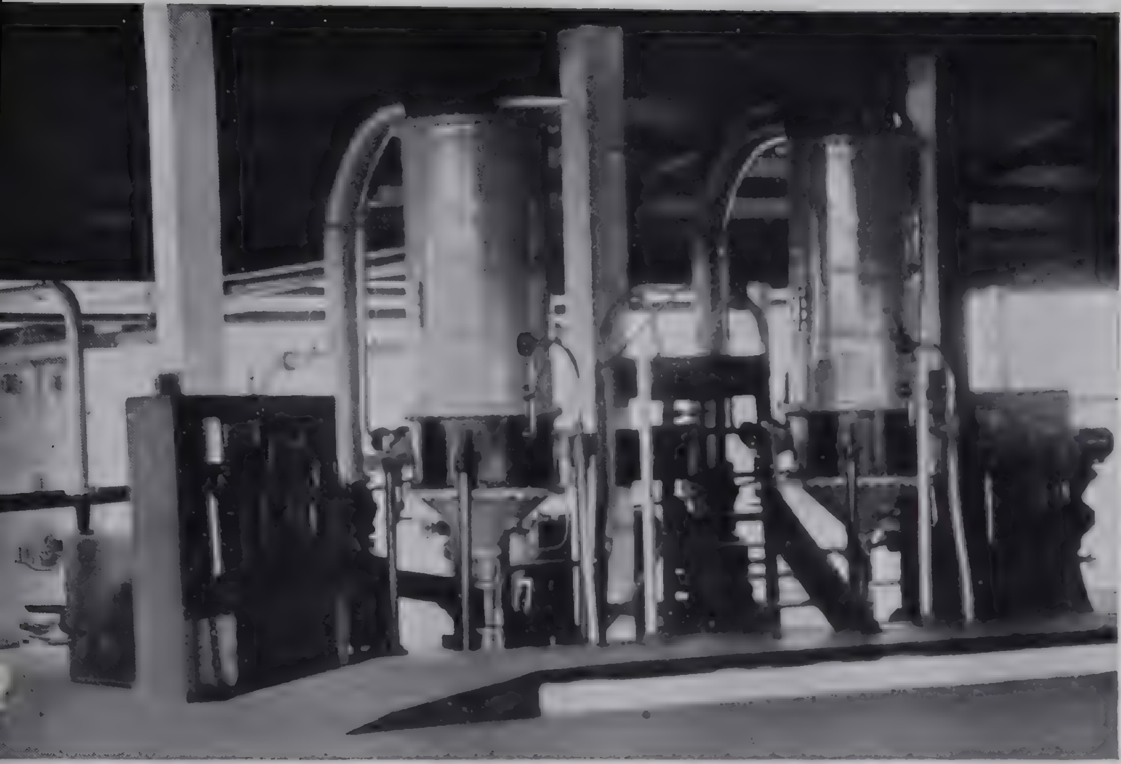


Fig. LV. Lemale Evaporator

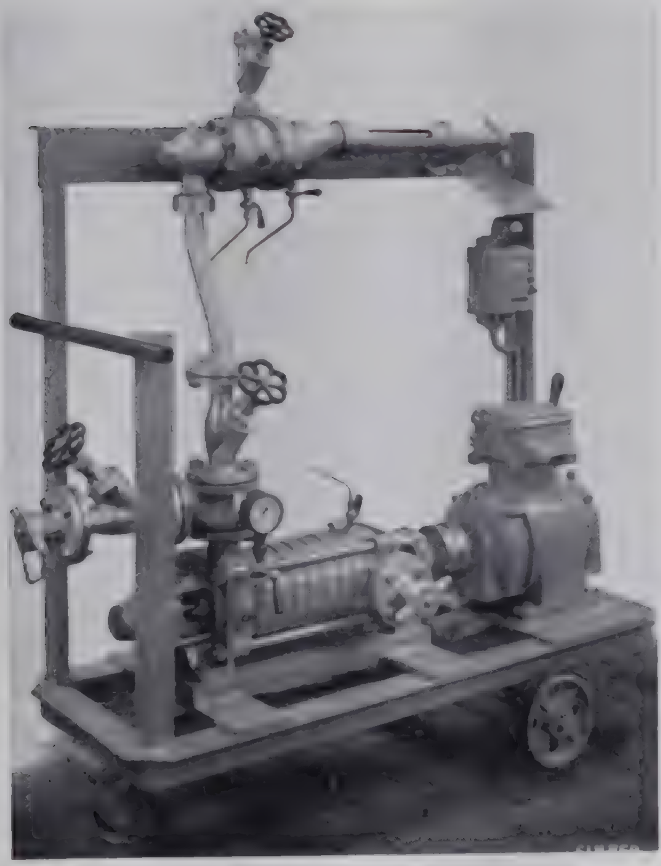


Fig. LVI. Swiss Sulzer Impregnating Pump for Storage of Apple Juice

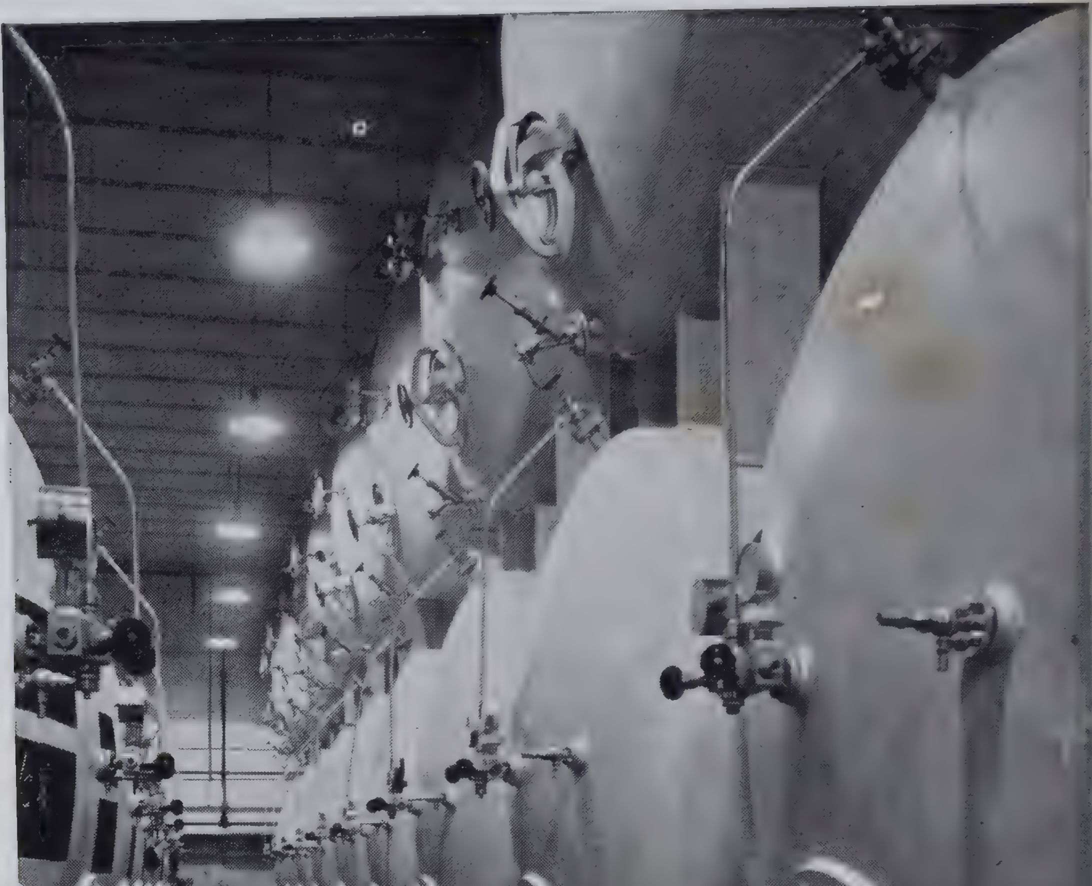


FIG. LVII. Prodor-Glas Lined Storage Tanks for Unfermented Apple Juice

e able to command a high price; they clarify well and retain
eir high qualities over long periods, being in all respects
perior to ciders from fruits grown on the other areas.

ATURALLY SWEET CIDERS PRODUCED BY SPECIAL PROCESSES

(*a*) *Special Yeasts* (*without sucrase*).—Kayser and Alliot have
commended the use of special cultures of yeasts which contain
sucrase and which cannot therefore ferment the sucrose in
e juice. The fresh juice must necessarily be pasteurised before
eing inoculated and it is essential to choose juices that possess
gh sucrose contents (minimum of 4%). The process is not
sy to carry out for it is an important condition of success that
e juices should clarify efficiently after pasteurisation, and this
not generally a feature of sweet or bitter juices.

(*b*) *Special Yeasts* (apiculatus type).—Gimel and Pique advise
e application of yeasts with only feeble fermentative powers
Pseudo-saccharomyces apiculatus asporogenes) in the presence of
nall amounts of sulphur dioxide. Fresh apple juice is treated
ith 1½ oz. sulphurous acid per 100 gallons and allowed to re-
ain in a still condition for 18-24 hours, during which clarifi-
ation is usually effective. The cleared juice is inoculated with
very active culture of an apiculatus yeast. When the gravity
alls to 1·012, a slight addition of sulphur dioxide (1¼ oz./100
allons) prevents further fermentation and induces final clari-
cation.

(*c*) *Warcollier's Method I.*—Warcollier sought to examine the
roblem by the application of quite different principles; the
econd of the three methods due to this worker is considered by
im to be the best and to be productive of excellent results.

Warcollier's first method is based on the principle that it is
ossible to stop the fermentation process at any given moment
y starving the yeast cells by removing the assimilable nitro-
genous constituents in the juice. After the keeving of the juice,
he primary stage of fermentation is conducted in the presence
f air by direct aeration of the juice. In this way, the develop-
nent of the yeast is encouraged; the cells multiply at a quick
ate and the weight of yeast is enormously increased. Very little
alcohol is formed during this process. If all the nitrogen of the
uice is assimilated into the yeast cells, it merely becomes neces-
sary to rack the liquor with care and thus to remove both the

entire yeast crop and the nitrogen compounds of the juice. Th racked liquor, thus deprived of one of its essential elements, wil not subsequently support fermentation.

Apple juice is naturally low in nitrogen, containing an average of 0·01 %. Dried yeast contains 9-10 % by weight of nitrogen. To exhaust a juice containing 0·01 % of nitrogen it wi be sufficient to produce 1 g. of yeast per litre, which is quit capable of achievement in practice.

The practical details of the process are as follows: the deve opment of a brown head with subsequent clarification shoul be achieved in shallow vats open to the air. The juice is racke (with air contact) and led to an open vat where a light scu will form almost exclusively as a result of yeast action. Th scum is removed by some skimming device. One or two da later, the juice is racked into an open vessel, leaving behind a the deposit. The liquor is again skimmed, and the cid fermented in the usual manner, using either a prelimina fining or filtration to remove completely the yeasts from th medium.

The method is not universally applicable to all ciders. T succeed, high gravity juices (1·065-1·070) should be chosen wi an appreciable acidity which should be greater than 0·3 Insufficient aeration may lead to a too rapid initial alcohol fermentation. With low acid juices of the Normandy type, t tannins often oxidise too rapidly in the air, and there may a tendency for excessive darkening.

For these reasons, the second method of Warcollier is of mo general use.

(*d*) *Warcollier's Method II.*—This method is based on the b haviour of yeast when placed in aerobic or anaerobic conditio (*Comptes Rendus de l'Académie des sciences*, 26th June 1905). Den Cochin has established that yeast cannot live indefinitely wit out air. At the end of four culture treatments, or five as absolute maximum, the yeast has lost its fermentative pow Pasteur, in his classical experiments, showed that by fermenti a liquid with the complete absence of air and with only tra of yeast, it is possible to extend the fermentation period ind finitely, or, in other words, to produce a liquid which still tains some natural sweetness.

More recently, Mazé has shown that the life of yeast und

erobic conditions is limited, because the zymase which de-
nposes the sugar into alcohol and carbon dioxide disappears
vly under these conditions. The inactivation of the enzyme
ves a variable amount of sucrose which is not decomposed
l this sugar contributes to the ultimate sweetness of the cider.
is process is so effective that it is possible to provide a cider
ıt retains the required sweetness merely by regulating the
tial amount of yeast and its multiplication by the controlled
roduction of air.

Warcollier consequently considered that the best method of
oducing naturally sweet ciders would be to prepare a sterile
ple juice, induce an effective clarification in it, inoculate with
small quantity of yeast and maintain the liquor completely
e from air during the whole of the fermentation process. The
rmentation should then come to a natural conclusion before
e sugar is completely removed. By racking the cider with ex-
usion of air, it should be possible, on *a priori* grounds, to obtain
sweet cider which should retain indefinitely the characteris-
cs and organoleptic qualities it had acquired from the fermen-
tion process.

To verify these conclusions, Warcollier experimented with
juice which had been sterilised a year previously by being
eated three times to 65°C. at twenty-four hour intervals. The
ice was filled quickly into bottles of 1 litre capacity. The bot-
es were filled almost completely and closed by means of a
ıbber bung pierced with two holes, the one holding a tube to
lease carbon dioxide from the bottle and which dipped into
vessel of water, and the other for a glass tube to lead a current
carbon dioxide to the surface of the liquor in the bottle.

The bottles were inoculated with a vigorous cider yeast iso-
ted in Warcollier's laboratory. Some bottles were treated with
o cc. juice in full fermentation, and others with $\frac{1}{200}$ cc. each.
he former treatment provided a heavy inoculation of yeasts,
hilst only traces of yeasts were associated with the alternative
eatment.

The same day that the bottles were inoculated, an exactly
imilar set of bottles was prepared with loose cotton wool plugs
nstead of rubber corks. The experiments lasted 44 days, after
which the residual sugar and alcohol were estimated. The figures
re given below:

	Gravity	*Residual Sugar as % Glucose*	*Alcohol % by Weight*
Control	1·048	10·51	0·0
No. 1. Anaerobic fermentation (Traces of yeast)	1·031	6·15	2·01
No. 2. Anaerobic fermentation (Much yeast)	1·005	0·77	4·81
No. 3 Aerobic fermentation (Traces of yeast)	1·004	0·58	4·81
No. 4. Aerobic fermentation (Much yeast)	1·004	0·61	4·81

At the end of 44 days, cider No. 1 was quite clear and t fermentation had already ceased eight days previously; the tas was good but excessively sweet. Ciders Nos. 2, 3 and 4 we fermented almost to dryness, they mained cloudy and were generally inferi to No. 1. This cider, racked without contact and in the presence of carbon oxide, became stable and would not su port any further fermentation.

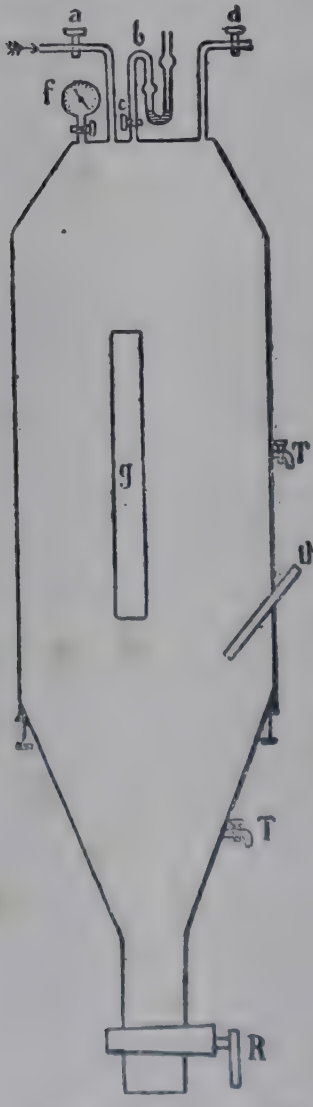


FIG. LII. Special Fermentation Vessel

The practical applications of these scie tific principles are now to be consider

The juice must be clarified by keevi with or without defecating agents, with t exception of calcium phosphate which courages fermentation. The clarified liqu should be racked with exclusion of air a introduced into a fermentation vessel w a special design (Fig. LII). The cylindri vessel is conically shaped at its lower e and is terminated with a cock R. The t is completely closed but communicat with the outside is achieved by 4 c nexions.

(i) tube (*a*) fitted with a tap, for entry of carbon dioxide.

(ii) a tube fitted with a fermentat lock filled with water (*b*) and a tap (*c*)

(iii) a tube with a tap (*d*).

(iv) a pressure gauge (*f*).

he central portion of the vessel is fitted with sight glasses the observation of the clarity of the cider, and thermometer The vessel should be constructed in cement, lined with some rt material, or in wood similarly treated, or, finally, in some tal lined with tin; the whole apparatus should be supported a frame to facilitate racking.

To encourage a slow fermentation, the juice should be cooled 2°-3°C. before entering the vessel and the whole process ould be conducted in a room maintained at 4°-5°C. The juice it is run into the vessel contains very little yeast material and mentation proceeds slowly on account of the low temperature the juice. In a short while, precipitation of minerals, pectins, nnins and albuminoids commences; the flocculation consement on this insolubilisation causes a further removal of yeasts om the medium. At this stage, the deposit is removed from the ssel by means of the bottom vent R; great care must be taken ring this process to prevent access of air into the vessel rough the fermentation lock (*b*). A stream of carbon dioxide passed in through the tube (*a*), the excess passing out through e bubbler (*b*).

Similar phenomena of fining and precipitation again take ace after a variable interval, and the deposit is again removed. nally, the cider will be practically free from yeasts and those lls that remain, having existed for a long period without ntact with air, will have lost their diastatic power and e thus incapable of fermenting the residual sucrose of e cider.

Such an apparatus employed in this manner will furnish ear, sweet ciders with very pronounced aromas, for all the uity character will have been retained. The cider is then suitble for bottling, filling into casks or for storage in cellars for long period. Such cider cannot acquire any taint from the es, neither will any bitter taste be imparted to it by yeasts at e completion of the fermentation when the cells plasmolyse. arkening is not to be feared, in view of the complete absence f air throughout the rackings and fermentation.

Warcollier recommends this process to the cider industry as ne that has been very thoroughly tested. For its most successful ploitation, however, it is necessary that the industry should stablish in its factories the low temperature cellars similar to those with which breweries are equipped and in which all fermentation processes can be adequately controlled.

(*e*) *Warcollier Method III.*—Excellent results have been obtained in the Caen laboratory with this method (Internationa Sugar Congress, April 1908). Under anaerobic conditions, th zymase in yeast is rapidly destroyed as the temperature approaches 37°-40°C. Consequently, if a liquor containing sucros is fermented anaerobically at 37°-40°C. and in the presence only traces of yeast, the fermentation will soon cease, leaving solution which still retains a proportion of the original suga

In laboratory practice, well clarified juices containing on traces of yeasts are fermented in the absence of air at 38°C Within eight days at this temperature the zymase is destroye and fermentation is completely inhibited. By commencing wit juices containing about 12% of sugar, ciders retaining 4-5% sugar have been obtained. When fermentation ceases, the cid is rapidly cooled to 15°C., clarification takes place, and th deposit is withdrawn by a normal racking.

(*f*) *Ultra-Violet Light.*—Warcollier and Maurain (Academ des sciences, 12th July 1909) have shown that fermentation ca be stopped by exposing pure cider in a thickness of 0·25 mm to ultra-violet light for two or three minutes. For cider dilute twenty times, and in thicknesses of 1·75 mm. an exposure of on to two minutes is sufficient. The exposure time is sometim even longer than this, due to the fact that the absorbing pow of the cider itself prevents the rays exerting their sterilising effe on the yeasts in the more remote parts of the cider.

(*g*) *Action of Pressure.*—It has been recognised for a long tin that ciders possess longer life in bottles than in casks, and the same way it has been pointed out that provision of vesse in the cider factory capable of withstanding pressure would l of great usefulness for storage purposes. O. Grove (*Ann. Re Long Ashton Res. Sta.*, 1922, p. 99) confirmed in 1922 that t action of pressure on the rate of fermentation of ciders durir the last stages was to retard the yeast action. The main ferme tation proceeds much slower under high pressure than at atmo pheric pressure. Such storage could usefully be employed l cider-makers as an alternative to some of the other metho described here for maintaining cider in a sweet condition.

CHAPTER XVII

NFERMENTED APPLE JUICE AND CONCENTRATE

has been seen in the previous chapter that one of the ways
which naturally sweet ciders can be offered to the consumer
n the form of a blend of a dry cider with a completely unfer-
ented juice, the latter being practically in the state in which
is expressed from the fruit.

There are many advantages accruing from the ability to store
nfermented juice from one season to the next. Production can
regularised from seasons of plenty to seasons of short crops.
rplus stocks can be built up in the cellars of large factories
in co-operative undertakings. This facilitates trading, for
ices are stabilised and the clientele is more constant because
the standardisation of the product that can be offered.

From another point of view, the stabilisation of the juice in
unfermented state enables the cider-maker to proceed with
s fermentation at leisure and not only during the actual
aking season.

The use of sterile juices removes any fear of the development
f disorders in the ciders, since the causal germs would be des-
royed or removed.

Finally, the sterilisation of apple juice in its natural state
ould lead to fresh outlets and more extensive trade. The cider
ndustry, more than any other, has need of wider horizons and
y the use of sterilised juices it can develop a profitable export
arket without the use of refrigerated transport.

One new market that has a very bright future is that con-
erned with the consumption of natural, unfermented apple
uices. The industry was born in Switzerland, for in 1896 non-
lcoholic ciders and perries were offered for sale, although under
uite inappropriate designations. The products were filtered
uices, sterilised by Tyndall's method—i.e. discontinuous heat-
ng at 55°-60°C. Unfermented apple juice has now been exten-
vely developed in Switzerland, North America and European
ountries, where grape juice is also consumed either under its

own name or as non-alcoholic wine. The consumption of these products is bound to increase, especially where teetotal organisations flourish. In England, certain cider factories sell sterile, carbonated juices under such titles as Sydrina, Cydrax, Sparkling Cidro, etc.

These apple products could replace with advantage the numerous syrups and liquors which are consumed in France i the summer months. In the south of France, grape juice wa already being consumed in 1928, and it is absolutely certai that apple juice will in time become equally popular. Englan and the Scandinavian countries would become useful outlet for French products.

Concentrated juices are concerned with one phase of unfermented apple juice production. The final product occupies onl one sixth or one seventh of the volume of the original juice an may contain up to 70% of sugar. The cost of transport of straigh juice may be so high as to prohibit certain transactions, and i such cases, the transport of a concentrate may achieve the reduction in cost necessary to secure an economic business. I effect, 1000 lb. of juice after concentration only weighs abou 170 lb., showing a saving of 830 lb. in weight. These concentrates can be exported for later dilution with water and subsequent carbonation, or for fermentation with pure cultures o cider yeasts. This method of using surplus apples is vastl superior to selling French apples in wagons to neighbourin countries for conversion into cider. Finally, concentrated appl juices can be used in the preparation of liqueur ciders, produc prepared exclusively from alcohol and apples.

The various methods of preserving apple juice will now b reviewed.

Centrifugation

In 1922, Warcollier attempted in the laboratory to clari and sterilise apple juice by using the Sharples super centrifug rotating at 36,000 r.p.m. Fresh apple juice as it comes from th press clarifies only with difficulty, and absolute clarity is n achieved in all cases even by the use of a centrifuge.

If, however, the fresh juices are submitted first to a keevin process, centrifugation will then always produce perfectly cle uors. Samples incubated at 25°C. for fifteen days show no ns of fermentation. They are practically sterile.

Similar experiments carried out in a large factory with a arples commercial machine, rotating at 16,000 r.p.m., showed at the machine delivered a sterile juice, but samples collected large vessels and casks developed fermentation due to con-mination in transference to the vessels.

The original laboratory experiments were repeated in an mosphere of carbon dioxide to avoid the intense aeration hich would otherwise affect the product. Similarly encouraging esults were obtained.

In 1926, a completely closed Sharples centrifuge was used for further series of experiments in which the juice was continu-usly maintained under a light pressure of carbon dioxide. Certain keeved juices at a gravity of 1·046 were centrifuged in December 1926, and in June 1927 the gravity had only fallen o 1·044, whilst the control juices had become dry (see pages 99-201 and Figs. XLVIII and XLIX).

The experiments were not entirely conclusive, but the defi-iencies in the method were probably due more to lack of terility in the containers than to the inability of the centrifuge o perform its function efficiently. The method should be developed by further research.

Pasteurisation

The Rosenstiehl method is to apply successive pasteurisation reatments between 55°-60°C. in an atmosphere of carbon dioxide to avoid the cooked taste. The method was applied in the Auge district but no developments arose from the preliminary work.

Warcollier, using a Salvator machine in 1904-5, established that sterility could be obtained by heating once to 65°C. or twice to 60°C.; heating above 65°C. produced a cooked taste in the juice; and whilst ciders made from pasteurised juices had no similar taste, there was a certain hardness in the product which was characteristic of the heat treatment. Some juices became permanently cloudy as a result of pasteurisation, and, further, they were extremely difficult to clarify. The pectins and albuminoids were in a physical state that rendered their coagulation most improbable, and these compounds passed through a pulp filter without changing their original colloi state and consequently without being precipitated on the fil medium.

In 1920, Warcollier re-examined the problem using a co mercial Salvator machine which has already been mentio The juices were heated to 78-80°C. ('Pasteurisation of ap juices and ciders', *Cidrerie française*, June 1920) and acquired cooked taste. Any lack of success that was noted in the expe ments could be attributed to incomplete sterility in the c tainers used for the pasteurised juices. Where fermentation ar it was always incomplete, the gravity of the resulting ciders ways remaining constant at about 1·010. Analysis showed t pasteurisation had removed certain assimilable nitrogen co pounds which were necessary for complete yeast action.

In one case, sterility was successfully accomplished by p teurising a juice which had been treated with 200 p.p.m. sulp dioxide.

The most recent work of Warcollier, using a Depaty a Gasquet machine has shown that the sterility of the container of fundamental importance and that whilst satisfactory stora may be achieved with small barrels, storage in large vats is mu more difficult.

Preparation of Unfermented Apple Juices

In the first place, attention must be drawn to the fact th 'non-alcoholic ciders' (*cidres sans alcool*) is an incorrect title these juices. The word 'cider' should be excluded from the ti of the product.

The industry of unfermented juices began at Meilen, n Zürich, in 1896, as a result of the investigations of Müll Thurgau. The consumption of unfermented apple juice has veloped in Switzerland, America, Canada, England, Holla Germany, Sweden and Norway, and its development can a be traced in all countries where the consumption of alcoholic spirituous beverages is forbidden or where temperance and t total leagues and organisations are very powerful. The ci industry should not spurn such sections of the public, but sho attempt to supply their particular needs. The French indus should turn its attention to exporting to countries where

ements are of importance and with special reference to
ammedan areas.

erilisation by Heat.—This method is in general use and the
litions have already been given for successful treatment. The
es used should be medium sharp with only a little bitter
acter. The fruit must be pressed with expedition, and the
e cooled as quickly as possible both to prevent the onset of
nentation and to obtain a rapid settlement of the deposit.
teurisation follows at 65°-70°C. for 30 minutes, and the pas-
rised juice is filled into 7-10 gallon casks that have been care-
y sterilised. The pasteurised product should be stored in
ars at 10°-12°C. Clarification with gelatin can be used and
s advisable to complete the process of clearing with an effi-
nt pulp filter. The clear juice can then be bottled and pas-
rised.

Carbonated juices can also be produced. Light carbonation
ls for a pressure of 12-16 lb. per sq. in. in ordinary bottles
sed with crown corks. If double this pressure is used, cham-
gne type bottles should be employed and these should be
steurised in autoclaves to equalise the pressure inside and
tside the bottle.

Other Procedures

(i) An American method comprises clarification with diato-
aceous earth (5 lb./100 gallons) followed by filtration to a
illiant condition and filling straight into bottles from the pas-
urising machine. This method is suitable only for sharp apples.
uess, either alone or in collaboration, has published numerous
pers on unfermented juices. Gore examined the possibility of
eezing juices at −10°C. Hite and Gidd have shown that juices
bjected to very high pressures can be preserved from fermen-
tion.

(ii) Fruit juices in the United States can be preserved with
dium benzoate (0·1%). This country, prior to 1928, attemp-
d to prevent importation of sterilised juices which were cap-
ble of producing more than 1·0% of alcohol if water was added
nd fermentation induced in the product (Fordney legislation).

(iii) *Action of formol.*—Perrier recommends the washing of
ne fruit with a 0·9% solution of formaldehyde for 10 minutes;
ne subsequent milling and pressing should be effected by ap-

paratus that has been thoroughly washed with a 0·4% sterilising solution.

The juices will then be practically sterile, and ciders produced from these juices will either contain no formaldehyde a all or only faint traces. This procedure should have many advantages from the economic point of view, but it is essential t remove all traces of the sterilising agent, for the French law o 1st August 1905 forbids the presence in cider of formaldehyde even in traces.

(iv) *Oxygen under pressure.*—Malvezin and Grandchamp hav suggested the use of oxygen or nitrogen gas, under pressure, fo the prevention of fermentation in apple juice. In the case o oxygen, the gas is diffused into the juice through porcelain candles at a pressure of 50 lb./sq. in. About 100 volumes of oxyge are needed for 1,000 volumes of apple juice. The juice is store under 80 lb. pressure in special containers. The originators o the method claim that yeast and enzyme growth is inhibite and that fermentation is entirely suppressed. Warcollier, however, could not obtain satisfactory results with this method.

(v) *Sulphur dioxide.*—Alliot and Jacquemin recommend th use of sulphur dioxide at the rate of 200 p.p.m. These worker claimed that juices could be kept in an unfermented conditio until the summer following the making season. Fermentatio after storage of the juice preserved for nine months could b effected by using a vigorous strain of a normal cider yeast, bu if the preserved juice was to be fermented in a short time afte preservation, then it was essential to use a starter of a pure yea acclimatised to sulphur dioxide. (The starter is made by commencing with a solution of sugar in water, to which tartar acid and mineral salts have been added. The solution is maintained at 20°-25°C., whilst gradually increasing doses of sulphu dioxide are added. In this way, a yeast can be acclimatised sulphur dioxide in twelve hours.)

Warcollier has repeatedly found that 200 p.p.m. of potassiu metabisulphite is insufficient to obtain sterilisation, and that fiv times that quantity is actually necessary. Lesser quantities a lowed fermentation to develop after periods varying from one six months. (In these cases, the juices were free from air conta and were stored at temperatures which never exceeded 15°C

Where spontaneous fermentation occurred with sulphur d de treatment, Warcollier noted the three following points:

a) The sulphur dioxide originally in the juice is almost en- ly recoverable from the fermented cider. A range of juices taining 475, 372, 343, 127 p.p.m. sulphur dioxide after fer- ntation produced ciders with 423, 340, 302 and 104 p.p.m.

b) The sulphur dioxide passes from the free to the fixed con- ion during fermentation.

(c) Fermentation does not commence until the transforma- n of free sulphur dioxide to the fixed form has taken place.

(vi) *Warcollier's Method.*—The late Director of the Cider Re- arch Station at Caen has developed a method which does not ow of the possibility of fermentation in the preserved juices. Varcollier, 'The rôle of sulphur dioxide in cider-making'. *Bul- in Assoc. franç. pomologique*, 2nd volume 1908 and 2nd volume 13). The principles of the method are outlined below.

(*a*) It is necessary to recall that when sulphur dioxide is added a juice, part of it passes into the fixed form which plays no fur- er rôle as a preservative, whilst the rest remains as free sulphur oxide. It is this fraction of the sulphur dioxide that inhibits east growth according to the quantity available (complete in- bition is obtained with 100 p.p.m. free sulphur dioxide).

(*b*) Only sound fruit should be used; all rotten or heated pples must be rejected. The fruit should be washed in water ontaining 5 oz. calcium hypochlorite per 100 gallons and later nsed with pure water.

(*c*) Very clean apparatus must be used for juice extraction. he maceration of the fresh pulp should be carried out in the resence of sulphur dioxide and the surface of the pulp may also e sprayed with a sulphur dioxide solution so that 0·4 oz. of lphurous acid is used per ton of pulp.

(*d*) The final preservation of the juice should be effected with quid sulphur dioxide (and not with potassium metabisulphite) t the rate of 1 lb./100 gallons of juice (1,000 p.p.m.).

(*e*) The preserved juice must be stored under ideal conditions f cleanliness; the casks should be quite full, and the cellars as lean and fresh as possible.

(*f*) The free sulphur dioxide content of the juice should be stimated each month and not allowed to fall below 100 p.p.m. Should the percentage fall, more sulphur dioxide must be dded.

(*g*) The sulphited juice should be held in wooden vessels and not in lined concrete tanks.

A sulphitometer can be used for introducing the sulphur dioxide, but for large volumes of juice a 6% sulphur dioxide solution should be prepared in a wooden cask, the solution being thoroughly mixed into the larger bulk of juice.

Sulphur dioxide can also be introduced into a juice by a copper tube perforated with a large number of small holes through which the gas can diffuse. The actual amount of sulphur dioxide used can be checked by weighing the sulphur dioxide containers before and after they are used, and a further check is possible by estimating the sulphur dioxide by chemical means a few days after the preservation process.

Utilisation of the Preserved Juice.—The juice thus preserved with sulphur dioxide can be used to sweeten dry ciders (provided that the total sulphur dioxide content of the blend does not exceed the legal limit of 200 p.p.m.) or the sulphur dioxide can be removed prior either to blending in any proportion with dry cider, or being fermented by addition of a yeast starter.

The sulphur dioxide can best be removed in a vacuum at 50°C. A very slow evaporation should be achieved so that the sulphur dioxide is removed with the vapours. This process not only removes the sulphur dioxide, but also relieves the juice of its aroma, and ciders produced from the de-sulphited juices will not retain that fruity character which is essential for high class products.

Special apparatus is made in France by the firm of Barbet for the removal of sulphur dioxide (Fig. LIII). The sulphited juice is contained in vessel A and is drawn into the de-sulphiting column D by the vacuum maintained therein. The vapour is carried away through the tube E to the condenser F. G is a vacuum pump, whilst J is an extraction pump to remove the condensed vapours.

The later work of Warcollier has illuminated some obscure points concerned with the treatment of sound or over-ripe and damaged fruit. ('Considerations on the use of sulphur dioxide in cider-making': Congrès de Chimie industrielle, September 1915. Published in *C.R. Académie des sciences*, t. CLXXIV, p. 634, 27th April 1922.)

(*a*) *Juice from Sound Apples.*—Sulphur dioxide added to apple

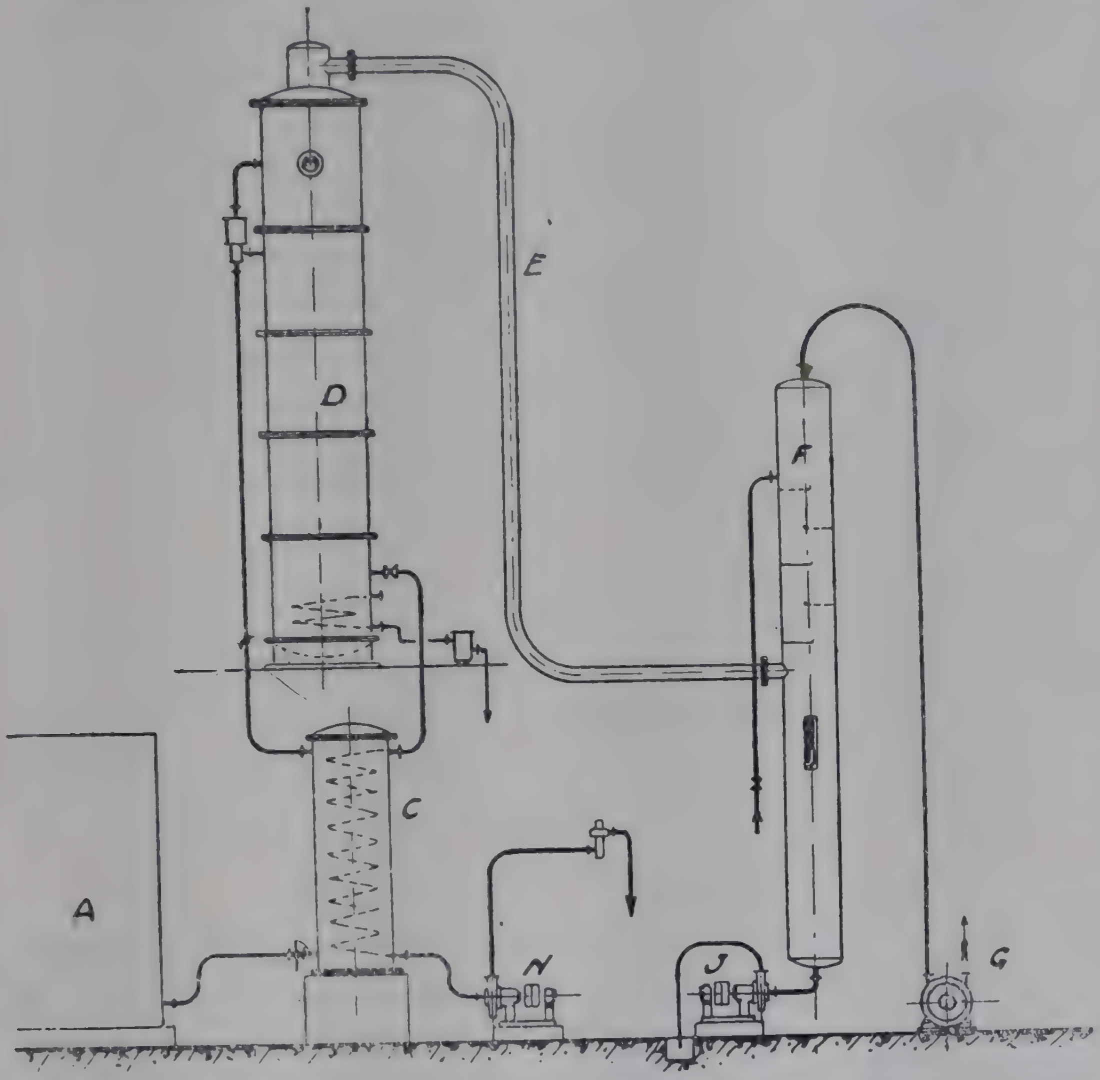


FIG. LIII. French Continuous De-Sulphiting Machine (Barbet Type)

juice at the rate of 0·1% (1,000 p.p.m.) combines with certain constituents of the juice, principally the sugars. The process is slow and gradual in the case of laevulose and glucose, whilst sucrose has no power of combination with sulphur dioxide. The amount of sulphur dioxide which is combined in this way seldom exceeds 0·1% on the weight of reducing sugars present. Consequently, the greater part of the sulphur dioxide (about 50% of the total) remains in the free state. A juice of this type can be relieved of the greater part of its sulphur dioxide by a slow evaporation under reduced pressure.

With the passage of time, however, the free fraction of sulphur dioxide gradually decreases and the removal of the preservative becomes progressively more difficult, especially after the end of the first year's storage in a sulphited condition.

(*b*) *Juice from Over-ripe or Damaged Apples.*—Sulphur dioxide added to such juices behaves in a different way from the former case. It is combined in a special way to the extent of 80-90% of the total sulphur dioxide present, this combination occurring during the first month. This exceptionally high fixation is due to the presence in apple juice of this type of certain abnormal constituents formed as a result of mould action in the decomposed fruits. These active 'fixing' substances include small quantities of aldehydes with boiling points below 100°C. and aldehydes which are more stable at this temperature.

A sulphited juice made from very poor quality apples, if submitted to vacuum evaporation, will lose the following fraction of sulphur dioxide:

(i) its free sulphur dioxide;
(ii) sulphur dioxide combined with the volatile aldehydes
(iii) only a part of the sulphur dioxide in combination with the stable aldehydes.

Consequently, there can be no complete removal of sulphu dioxide in this type of juice, even after prolonged boiling.

Concentration of Juices by Heat

Concentration of fresh apple juice diminishes the volume an weight of the original product, and thus reduces the cost storage, handling and transport and ensures the safe keeping the juice, provided that the concentration is taken to a sufficiently high degree to avoid yeast development. To produce satisfactory concentrate, 748 gallons of fresh juice of a gravit of 1·050 should be reduced to 100 gallons of concentrate wit a gravity of 1·332 (36° Beaumé); i.e. a concentration of 7½ to 1

The physical, chemical and biological effects of heat on th constituents of apple juice are proportional to the degree of hea treatment to which the juice is subjected. Consequently, it i usual to evaporate at as low a temperature as possible, using vacuum evaporator to achieve this. The cooked taste is du either to decomposition of certain organic compounds in th juice, or to the oxidation of other materials susceptible to th influence of oxygen or oxidising conditions. Vacuum evaporation thus reduces both these effects. Metallic contaminatio should be avoided at all costs, especially when sulphited juic are to be evaporated.

Juices for concentration should be chosen for the ultimat urpose for which they will be used. For sweetening dry ciders, itter sweet cider apples should be employed. In such cases, it advisable to keeve the juices before concentration to remove he more easily precipitable pectin compounds; neglect of this recaution may result in the concentrates being very thick or elatinous as they issue from the evaporator.

Concentrates that are to be used for the production of unfermented juices by dilution should be made from medium-sharp ruit with relatively low tannin contents.

Sharp apple juices with acidities above 0·55% malic should be partially neutralised by adding calcium carbonate in such amounts as will prevent the acidity rising above 4·0% in the concentrate. The neutralised juice should be filtered before being evaporated.

In the production of concentrates which will be diluted and fermented into beverages of a cider type (a process not allowed in France, but permitted in certain countries), medium-sharp apples with an acidity of about 0·48% malic acid and a low tannin content should be chosen.

In all these cases, it is better to concentrate the fresh juice to which no sulphur dioxide has been added. The last two types of concentrate mentioned above should never be made from juices which contain more than 0·1% of sulphur dioxide.

In the event of it being desirable to lay down stocks of juice containing 0·1% sulphur dioxide for subsequent concentration, great care should be employed in their sulphiting, for only by adhering strictly to the conditions already laid down can suitable concentrates be made for eventual use to sweeten dry ciders.

Vacuum Evaporators

Apparatus designed to provide only low degrees of concentration will not be described, but attention will be focused on those machines that embody the principle of continuous concentration by achieving low temperature evaporation of the juice in the absence of air.

(*a*) *Single effect evaporators.*—These machines are composed of an evaporating chamber, heated by a nest of tubes or a coil heated by steam. The vacuum is provided by a special pump and the condensation of the vapours is effected by a condenser. It is preferable to combine the air pump and the condenser;

i.e. the ejector-air-condenser system. Many plants of this description are available, either designed specifically for apple juic or adapted from machines used for the evaporation of milk, sugar syrup, etc. The best known French makes include those of Egrot & Granger, Deroy, Navarre, Barbet, Kestner, Lemale, etc. A line drawing of a modern Barbet evaporator for apple juice is shown in Fig. LIV.

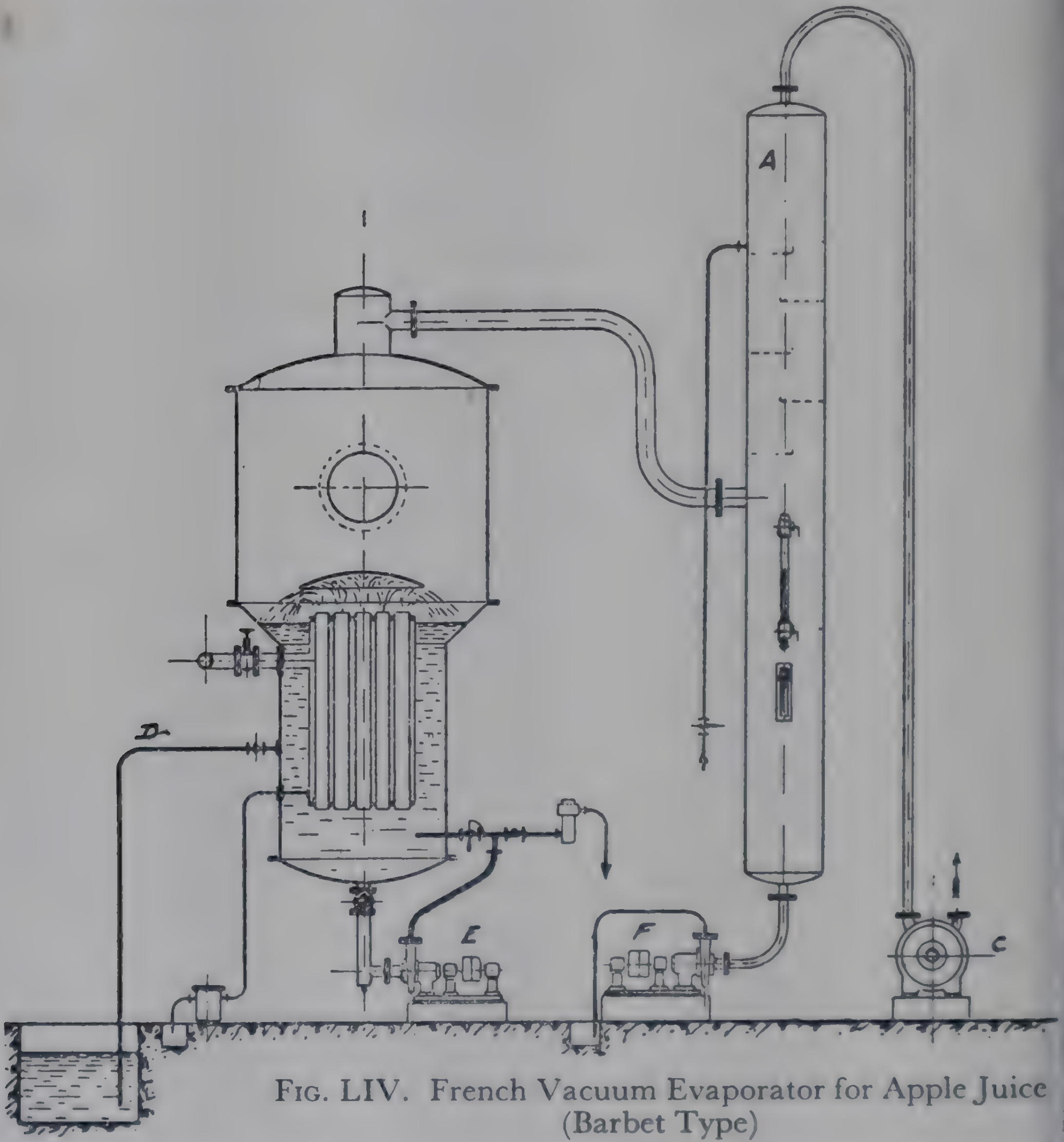


Fig. LIV. French Vacuum Evaporator for Apple Juice (Barbet Type)

(*b*) *Multiple Effect Evaporators.*—The first effect only is heated with direct steam, the other effects being heated by the vapour removed by the preceding effect, thus achieving a notable saving in fuel. The vacuum is applied only to the last effect. It is obvious that the greater the number of effects employed, the higher should be the temperature used in the first stage.

In the Barbet plant, the juice evaporates between 45°-50°C. in a single effect machine, whilst in the double effect evaporator the temperature reaches 70°C. during the primary evaporation, and 45°-48°C. in the secondary effect.[1]

The Kestner evaporator is made with ascending and descending flow. (See Translator's addenda for description of a modern Kestner plant.) The juice flows through vertical tubes, about 1 ft. long, each being enclosed in an outer enveloping tube supplying the steam. The juice enters the lower end of the heating tube, rises inside the element and then falls again through another tube. The concentrate and the vapour escape from the bottom of the tubes and pass through a centrifugal separator. The concentrate is removed by an extraction pump, the vapours being drawn off through the vacuum pump. The juice remains only a short time in the apparatus (about 1-3 minutes for this type of plant). The temperature of evaporation in a single effect plant is 45°C., the steam temperature varying between 80°-85°C.[1] In a double effect plant, the juice is concentrated at 90°-95°C. in the first effect and at 45°C. in the second. (The exact temperature will depend on the gravity of the juice and the concentration achieved in each effect.) When the vapours from the evaporator are not directly utilised, and when one has a suitable pressure and temperature drop available, the vapour can be compressed by an ejector-compressor which utilises the vapours of evaporation for heating the juice, and thus effects a very considerable saving of fuel.

Warcollier has used a Kestner evaporator at the factory of Molinié Frères at Saint-Sever (Calvados), and the results have been published. (Warcollier, 'Studies on the concentration of apple juice': *La Cidrerie Française*, August 1920.)

Prache and Bouillon have produced a special evaporator for the vacuum concentration of grape juice up to 35° Beaumé (specific gravity 1·319). The juice is subjected to 35°-40°C. only.

The Lemale evaporator (Fig. LV) has been examined by Warcollier at the Grande Cidrerie de Brest (Warcollier, 'Note on a machine for low-temperature concentration': *La Cidrerie Française*, June 1926). This plant works at a very low temperature. The heat is supplied through a calandria carrying low

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[1] Translator's note: Warcollier omits to mention the vacua at which the various evaporators are normally operated and the value of these descriptions is depreciated to some extent on account of this.

TABLE XX.—ANALYSES OF CONCENTRATED JUICES (1920)

	No. 1 *Fresh juice used to produce concentrates Nos. 2 and 3*	No. 2 *Concentrated juice (reduced pressure) Vac. = 13½″*	No. 3 *Concentrated juice (atmospheric pressure)*	No. 4 *Keeved juice treated with 0·04% sulphur dioxide; used to produce concentrates Nos. 5 and 6*	No. 5 *Concentrated juice (reduced pressure) Vac. = 13½″*	No. 6 *Concentrated juice (atmospheric pressure)*
Specific gravity	1·045	1·3316	1·2906	1·048	1·3428	1·2942
Degrees Beaumé	6	35·9	32·4	0·6	36·7	32·7
Sucrose %	0·84	6·15	5·25	0·84	0·42	5·45
Glucose %	1·87	14·30	11·95	2·68	15·85	13·65
Laevulose %	6·69	50·30	43·25	6·79	52·10	43·95
Total dry extract at 110°C. %	11·52	85·72	73·84	12·01	90·54	77·96
Total acidity (malic) %	0·30	1·71	1·46	2·88	1·77	1·46
Free sulphur dioxide %	Nil	Nil	Nil	0·0025	Nil	Nil
Combined sulphur dioxide %	Nil	Nil	Nil	0·0487	0·0280	0·0270
Total sulphur dioxide %	Nil	Nil	Nil	0·0512	0·0280	0·0270

essure steam at a temperature that is capable of exact regula- on. This is achieved by the use of an extremely efficient ejector- r-condenser.

Boiling occurs at 30°-34°C. provided that the temperature of e cooling water is never higher than 15°C. Concentration to ° Beaumé (specific gravity 1·331) can be achieved.

Analytical Data

Table XX gives the results of analyses of concentrates deter- ined by Warcollier in 1920. The experiments were carried ut on a single effect Kestner evaporator.

Table XXI shows the analyses of concentrated juices deter- ined by Warcollier in 1925 on products made by M. Derouet t La Guerche-de-Bretagne.

ABLE XXI.—ANALYSES OF CONCENTRATED APPLE JUICE (1925)

	No. 1 *Concentrate from sweet apples*	No. 2 *Concentrate from sharp apples*	No. 3 *Concentrate from sweet apples*	No. 4 *Concentrate from sharp apples*
egrees Beaumé	33·7	37·2	41·5	41·54
pecific gravity	1·305	1·347	1·405	1·400
cidity (% malic)	1·174	3·48	1·476	3·895
annin % - -	1·436	1·196	1·702	1·648
ectins % - -	0·750	1·150	1·150	1·250
educing sugars %	66·65	68·4	89·60	81·20
otal sugars % -	69·70	76·8	95·00	91·70
ucrose % - -	3·10	8·4	5·40	10·50
lucose % - -	16·80	18·1	21·80	21·80
aevulose % -	49·80	50·3	67·80	59·40
atio $\frac{\text{glucose}}{\text{laevulose}}$ -	0·337	0·36	0·32	0·36
sh % - -	1·12	1·45	1·50	1·67
otal dry extract at 100°C. % -	82·50	92·5	108·30	105·70

Utilisation of Concentrated Juices

The use of concentrated juices in France is complicated by the internal taxes applied by the Treasury (Warcollier, 'The concentration of apple juice in cider-making': *Bulletin Association française pomologique*, 1921).

In 1928, the concentrated products were controlled by a temporary decree. Numerous regulations by the Administratio sought to establish an equitable solution to the problem, agre able alike to the cider industry and to the Treasury. Th Government attempted to fix the tax at such a level that:

(a) illegal reconstitution of the concentrates and their ferme tation into cider would not produce a beverage that was cheap than cider, on which certain taxes are normally collected; an

(b) the use of concentrated juices for sweetening purpo would allow the State to recover, according to their sweeten power, an equivalent sum to that which it would receive fro the use of beet sugar. In 1928, the concentrated juices we classed as non-crystalline sweetening agents under Article of the law of 19th July 1880.

Concentrates can only be made by fulfilling the obligatio imposed on the makers of glucose and sucrose (Article 22 of t law of 21st May 1846). The taxes imposed in 1928 amount to 15 francs per 100 kilograms nett weight ('droit de circulati and 'droit de consommation').

The sweetening of ciders and perries by means of conc trates is officially sanctioned, although it is no longer includ in Article 4 of the decree of 19th July 1908.

The 36° Beaumé concentrates, containing 70%-80% sug should be used at the rate of 1-2% for blending with complet dry ciders.

In France, it is illegal to produce ciders by the fermentat of reconstituted concentrates, although this practice may employed in French colonies and foreign countries.

Warcollier has published a report on the fermentatio reconstituted concentrates (Warcollier, 'The study of conc trated apple juices': *Bulletin Assoc. française pomologique*, 19 He has produced dry ciders with alcohol contents betw 4·82-6·42% by weight, and ciders with 9·68% total alcohol utilising selected yeasts. It is advisable to rack the diluted c centrates before inducing the fermentation so that solid mate may first be removed. The production of ciders should only attempted from concentrates made from medium sharp ap

Concentrated juices which are to be used for the produc of unfermented beverages should be evaporated at very temperatures. The vitamins A and B are retained bette temperatures lower than 100° C. and the same is true, but

h greater extent, of vitamin C (see Translator's Addenda,
pter III, p. 50).

Stability of Concentrated Juices

lthough concentrates can be sterilised by heat, they are
le to show signs of instability on account of infection by
aneous organisms if the degree of concentration is not suffi-
tly high. Concentrates of 35°-36° Beaumé (specific gravity
9-1·331) are relatively stable and free from the influence of
st and moulds, especially if the medium is highly acid. But
nust be remembered that the exposed surface of the concen-
e will absorb water vapour, and become gradually so diluted
t it becomes a medium capable of supporting the develop-
nt of destructive organisms. Concentrates containing less than
% of sugar (approx. 32° Beaumé or 1·283 specific gravity)
exposed to the dangers of infection and should be sterilised
heat. Naturally, concentrates after sterilisation must be
ed in such a way that there is no contact with air. Clean,
d, metal tanks are most suitable for this purpose. Filtration
y possibly be used as a means of sterilisation if the application
eat is undesirable.

Transport of Concentrates

mall consignments of concentrated juices can be sent in glass
boys or demi-johns protected by wicker crates. Larger vol-
es, however, must be despatched in wood, despite the fact
t no matter how thick the staves in the casks, the concentrate
l eventually saturate the wood and leak away.

Varcollier has indicated the possibility of transporting con-
trates in tinned steel containers, as used for milk, but the
ation of contact must be short. The vessels should be care-
y cleaned after each journey and re-tinned immediately the
face shows signs of disintegration. Warcollier has also had
remely satisfactory results from the use of aluminium vessels
d with bakelite plastic. No alteration in aroma, taste or
mical composition was noted. Careful choice of the plastic
ecessary so that no residual free phenol is present to taint
product.

Concentration of Apple Juices by Freezing

This subject has been studied by Descours-Desacres. The aim of this work was not so much to preserve fresh juices entirely by concentration as to effect some minor degree of concentration in juices to which water had been added during the course of their production (i.e. in the re-soaking process). Either freezing in bulk or fractional treatment is possible.

Bulk Freezing.—The juice is cooled to – 3° or – 4°C. during 24 hours. The following fractions are capable of separation:

(*a*) by withdrawing the liquor from the ice at – 2°C., a product is obtained with 50% greater specific gravity than that of the initial material.

(*b*) withdrawal at – 1°C. provides a liquor with gravity equal to that of the initial juice.

(*c*) a final fraction can be separated at + 2°C. with a gravity of 1·014 and suitable only for production of apple drinks.

Fractional Freezing.—The juice is cooled to – 6° or – 7°C. with constant agitation. Products are then obtained similar to (*a*) above, and a further fraction of gravity 1·028-1·040 which can be used for apple drinks. This procedure is very costly and is not employed commercially.

Monti, in Turin, has concentrated grape juice by the application of refrigeration. The principle of his method is to centrifuge the mass of ice crystals and collect the adhering concentrated juice which is then taken to the desired final degree of concentration in vacuo by the application of heat. The process has been applied on a commercial scale in Italy and America by Monti since 1905, and has achieved an important success.

Monti utilises his process not only to produce concentrates, but for the production of syrups, jellies, grape honey, and solid sugars. Concentrated extracts of grapes are also prepared for imparting the colouration and flavouring of Italian wines to the Californian products.

In 1920 and 1922, Warcollier experimented with a Daubron refrigeration unit providing 7,140 B.T.U.s per hour. Whilst his method was based on that of Monti, Warcollier attempted to obtain more highly flavoured concentrates by operating a series of freezings at different temperatures. He was able to produce concentrated materials with fine aromas and very deep colours, but the limit of concentration was a reduction in volume of 4 to 1. Thus, juices with gravities of 1·050 could be concentrated to 1·200, and at that gravity they contained 45% of natural sugar. Products of this description must later be taken to a higher degree of concentration by vacuum evaporation.

Translator's Addenda

The most interesting and important development which has occurred since 1928 in connexion with the utilisation of apples for the production of liquid products has been the development of unfermented apple juice. The industry in the various countries concerned has developed largely as a means of utilising surplus fruit which was not suitable for the market, and which was not of the correct composition for the manufacture of the type of cider normally consumed in the respective countries.

Production on a large scale was first developed in Switzerland and this was followed quickly by a German industry which was fostered directly by the National Socialist regime. The importance placed on health and fitness by the Nazi Government led to the consumption of enormous quantities of unfermented apple juice, and a technique of production of the highest calibre was introduced in that country. In the ten years before the last war, the American industry, too, developed at a remarkable rate, but the quality of the juice in this case was by no means of such a high character as that of the Swiss and German beverages. The English industry did not commence until 1936, and developments were only just commencing to make themselves felt by the beginning of the war, and all further wartime expansion was vetoed by the Ministry of Food. The most recent figures in various countries for which accurate reports are available are as follows:

	Great Britain gallons	*America* gallons	*Germany* gallons
1932 -	—	—	6,500,000
1935 -	—	7,500,000	8,000,000
1936 -	15,000	7,700,000	5,000,000
1937 -	25,000	—	15,000,000
1938 -	45,000	—	21,000,000
1939 -	60,000	1,179,000	27,000,000
1940 -	100,000	1,518,000	—

	Great Britain	America	Germany
1941	150,000	5,178,000	—
1942	200,000	4,935,000	—
1943	200,000	5,219,000	—
1944	200,000	8,554,000	—
1945	200,000	3,946,000	—
1946	200,000	10,572,000	—
1947	400,000	3,542,000	—

The production of unfermented apple and pear juices Switzerland in the years 1942-3-4 was given by Dr. Ha Brugger in 1946 (*L'arboriculture fruitière et l'utilisation de ses pr duits en Suisse*) as:

	1942 gallons	1943 gallons	1944 gallons
Pear juice	1,995,270	709,000	744,600
Apple juice	1,305,720	3,718,810	4,715,790
Mixed juices	2,598,240	3,053,750	3,627,400
Total	5,899,230	7,481,560	9,087,790

The production of concentrated juices is given by the sar authority for the same years as follows:

	1942 tons	1943 tons	1944 tons
Concentrated pear juice (Theiler)	614	218	2,318
Concentrated pear juice (other varieties)	841	3,248	8,930
Concentrated apple juice	182	2,758	1,586
Concentrated mixed juices	93	189	192
Total	1,730	6,413	13,026

At a specific gravity of 1·330 (i.e. a concentration of 6½ to 1 ton of concentrated juice equals 170 gallons.

The output of dried pomace is similarly calculated as und

	1942 tons	1943 tons	1944 tons
Dried pear pomace	4,065	7,535	10,887
Dried apple pomace	910	6,013	4,344
Dried mixed pomace	103	110	426

The technique of production has been largely influenced the improvement in quality of the juice that is obtained maintaining a very low temperature from the time the juice

ressed until it is finally prepared for bottling. After the neces-
y clarification treatments have been undertaken, including
atment with pectinase enzymes and on some occasions fining
h gelatin, the juice is cooled, filtered to a brilliant condition,
d stored, after impregnation with carbon dioxide, in metal
ssels capable of withstanding considerable pressures. At room
nperature it is necessary to impregnate the juice at a pressure
120 lb. of carbon dioxide per sq. in., but if storage at lower
mperatures is available then this pressure can be correspond-
gly reduced.

Fig. LVI shows a well-known type of impregnating pump
anufactured by the Swiss firm of Sulzer. The storage tank is
st filled with water, which is forced out with carbon dioxide,
ter which the tank is filled with carbon dioxide to the required
essure. The juice is drawn in to the inlet of the pump and
rced through apertures which intimately mix the gas from
e tank with the juice, and the mixture is then pumped back
to the tank. A large installation (Fig. LVII) of tanks of this
pe is shown in the English fruit juice factory of Messrs. H. W.
arter & Co. Ltd., built in 1947-8, in which the tanks are of
ild steel, lined with Prodor-Glas, installed in a cool room
aintained at a very low temperature. Similar tanks to this have
een installed in Switzerland in 1948 and this type of lining
ppears to be eminently suitable for this particular purpose.

It is possible, by careful choice of temperatures and pressures,
retain sufficient of the impregnating gas in the juice after it
as passed through a sterilising filter to provide adequate car-
onation in the bottled product. The general procedure is to
asteurise the product in bottles at temperatures up to 70°C.
r periods not exceeding half an hour, after which the bottles
hould immediately be cooled in cold water. Fig. LVIII shows
large spray type pasteuriser of the Adlam type for pasteurising
pple juice or cider in bottle.

The Seitz method involves no heating of the juice whatever,
ut use is made of a sterilising filter which must, of course, be
ccompanied by completely aseptic conditions in filling machin-
ry, bottles and closures. A specially designed bottle sterilising,
illing and crowning unit has been built by John C. Carlson Ltd.
or this purpose and is illustrated in Fig. LIX. Whilst this par-
icular process provides juices with very fresh and attractive

flavours, the difficulties involved in the processing are legion. The cold process is used to advantage for large containers from which the juice can be dispensed in cafes, hotels, railway stations, etc.

Pasteurisation of fruit juices has received much attention with regard to the reduction of the cooked taste produced after juices are subjected to pasteurising temperatures over extended periods. The modern type of plant has been discussed in Chapter XIII (see Figs. XLVI, XLVII). Here, unfortunately, the most modern techniques of flash pasteurisation are not entirely helpful as it has not yet been found possible to flash pasteurise an aerated juice without loss of gas. The latest improvements in pasteurisation relate to the lowering of the pasteurisation temperature necessary for effective sterilisation by rendering the juice practically free from organisms before pasteurisation. By such treatments it is possible to use much lower temperatures for pasteurisation than were formerly the case, and apple juices of balanced chemical composition (i.e. without excessive acidities) can now be pasteurised in bottle with very little detectable deterioration in their fresh apple character. Following the American procedure of de-aeration as a means of reducing flavour changes during storage and also of minimising the effect of pasteurisation on flavour, experiments have been carried out along these lines with apple juice and sufficient evidence has been obtained to suggest that the previous de-aeration of a juice has a noticeable effect in these directions. A modern combined plant for de-aeration and pasteurisation designed specifically for fruit juices by The A.P.V. Company Ltd. is shown in Fig. LX.

Concentrated juices can be reconstituted with water for apple juice production. With the latest types of evaporators, which enable the volatile fractions to be returned to the juice, it is possible to obtain concentrated products which reconstitute extremely well. Such evaporators work at high vacua and correspondingly low temperatures. Such temperatures are often very considerably below that needed for pasteurisation and on this account the effect of pasteurisation on flavour is likely to be much more pronounced than that of concentration. As examples of modern vacuum evaporators (3, 4), three differing types will be described and illustrated. The Kestner machine is usually combined with a system for the separation and recovery of the volatile constituents of the juice that largely contribute to its aroma. (It is probable that the return of these constituents is not important if the concentrate is to be ultimately used for cider.) The actual contact of the juice with the heating surfaces is extremely short and in many cases is only a matter of minutes. All surfaces contacting the juice are made of stainless steel.

The juice, after removal of the volatile fractions, is fed to the first effect of the climbing film evaporator in which a number of tubes are heated externally in a calandria. A very efficient heat transfer is ensured by high velocity entry of the juice into the tubes, whilst the high vacuum maintained throughout the plant converts the solid bore of juice into a climbing film with a hollow core. The film rises until it is discharged tangentially into a separator where the vapour and liquid phases are separated. The process is then repeated twice again, each further effect comprising a smaller number of tubes, until the final concentrate is received in a catchpot under atmospheric pressure. Using a vacuum of 28″, evaporation occurs at 38°C. or less, and with very efficient condensation (calling for large volumes of water at 10-12°C.) the vapour temperature in the evaporator may be as low as 30°C. This evaporator is extremely efficient and can provide concentrated juices which, when reconstituted, are scarcely distinguishable from straight juices that have never been through a concentration process.

Figs. LXI and LXII show two views of the most important sections of a modern Kestner evaporator installed in 1947 in the fruit juice factory of Messrs. H. W. Carter & Co. Ltd. at Coleford. The first illustration shows the highest portion of the plant. In the left foreground is the 'ester' separator, into which the pre-heated juice is passed tangentially from the lower platform. The stainless steel tube leading from the bottom of the separator leads the liquid phase to the calandria for the evaporation of the water fraction. The 'ester' vapour is condensed in the horizontal condenser attached to the separator, and the distillate is collected in a small catch pot under atmospheric pressure. The three large separators in the background are graduated in size, the largest receiving the mixed vapour and liquor from the first effect. The condenser is situated in the right background, whilst the first and second stage steam vacuum ejectors are see with their respective gauges.

The second illustration (Fig. LXII) shows the working platform of the Kestner plant, with the pre-heater on the right an the three downpipes from the separators to the bottom of th calandria grouped around that feature of the plant. The whee valve for controlling steam supply to the calandria can als be seen.

Two of the many evaporators designed on other principle can be illustrated by reference to two machines of W. J. Frase & Co. Ltd. Fig. LXIII shows a stainless steel forced circulatio evaporator working with vacua up to $28\frac{1}{2}''$ of mercury. Th plant is capable of batch or continuous operation. This machin is heated by sub-atmospheric steam from a steam turbine; th condenser is of the jet type with low level extraction pum whilst the vacuum is produced by a two-stage steam ejecto This type of evaporator is particularly suitable for liquids tha become viscous at high concentration at low temperatures (i. 30°-40°C.). Fig. LXIV depicts a stainless steel, natural circulation, external calandria evaporator suitable for liquids tha foam considerably without being very viscous at the temperature of operation. The feature at the centre of the machine is vapour recompressor of the steam jet type which affords a economy of 30% in the steam consumption. A surface type condenser and mechanical vacuum pump are included in th equipment. Both these evaporators are suitable for apple jui evaporation.

Freezing Concentration

Certain improvements have been introduced into this proce in the past ten years, particularly by Krause in Germany. Th juice may be frozen in a large circular cell immersed in a refr gerant. The solid block of frozen juice is then centrifuged high speed and the concentrate is collected through a perforat outer surface. A more recent development enables the juice t be frozen by flowing over a series of internally refrigerated roll drums, the juice thereby being frozen into a thick ribbon fro which the concentrate can be obtained by continuous presse

The freezing process of concentration is still under examin tion as to its efficiency and economical possibility. The costin the process have been studied by Bilham (5) and details and strations of the two plants are given in a British Government OS Report (6).

REFERENCES

Unfermented Apple Juice

) Tressler, D. K., Joslyn, M. A. and Marsh, G. L. *Fruit and Vegetable Juices* (Avi Publishing Co. Ltd., 1939).
2) Charley, V. L. S. and Harrison, T. H. H., *Fruit Juices and Related Products* (out of print in 1947, but being revised and reprinted in 1949 by the first author for the Commonwealth Bureau of Horticulture and Plantation Crops, East Malling Research Station, Maidstone, Kent).

Concentration of Fruit Juices

3) Reavell, J. A., *Chemistry and Industry*, 56, 618, 1937.
4) Dixson, R. A., *Fruit Annual*, 1947-8, pp. 153-9.
5) Bilham, P., *Chemistry and Industry*, 57, 589-93, 1938.
6) 'Food Preservation with Special Reference to the Applications of Refrigeration'. BIOS Final Report, No. 275, Item No. 22, H.M. Stationery Office, London.

CHAPTER XVIII

SPARKLING CIDERS

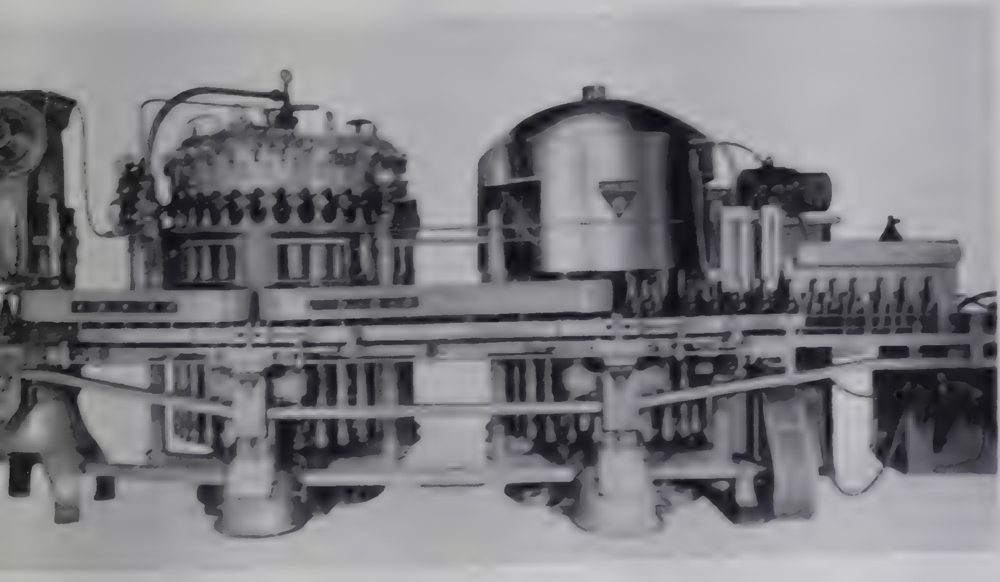
UNDER the French Regulations of 24th September 1933 no or perry may be held, transported or sold under the sp title of 'cidre mousseux' or 'poire mousseux' unless its gas entirely to a prolongation of the alcoholic fermentation pr This designation, therefore, must be reserved for ciders b at a specific gravity of 1·020-1·010 and treated as has prev been discussed, or for ciders subjected to the true cham fermentation process in bottle, which process will be deal in this chapter. The process is only suitable for large fac for it is not economic to undertake such processing or limited quantities of material.

Champagnisation Method

(*a*) *Choice of Cider.*—The raw material should be a cider, with a fresh, clean taste, full bodied and free from fication. Preference should be given to a clear produc duced by Warcollier's bottom fermentation procedure, the special type of fermentation vessel previously discusse cider should be completely fermented to ensure thorough fication; it is advisable to allow the ciders to remain in ca a year prior to bottling. Should the alcohol content be 4·8% by weight, sugar should be added both to provi necessary alcohol content and to ensure continuity of f tation. In the same way, the acidity should be raised to (as malic acid) by the addition of citric acid.

(*b*) *Priming the Cider.*—The prepared cider should be into clean casks and treated with a sugar syrup, a fining and a yeast culture. The sugar is added in the form of sugar syrup which has been carefully filtered through f To each 100 gallons of cider should be added 20 lb. sug 4 gallons of 50% syrup), ¾ oz. isinglass, 1½ oz. tannin gallons of yeast culture. The quantity of sugar needed process should be calculated in such a way as to produce

o. LVIII. Adlam Spray Type Pasteuriser of the In-bottle Type



X. Carlson Sterile Filling Unit, Comprising Bottle Sterilising Machine. 2-head Sterile Filter and 6-head Rotary Crown Corking Machine

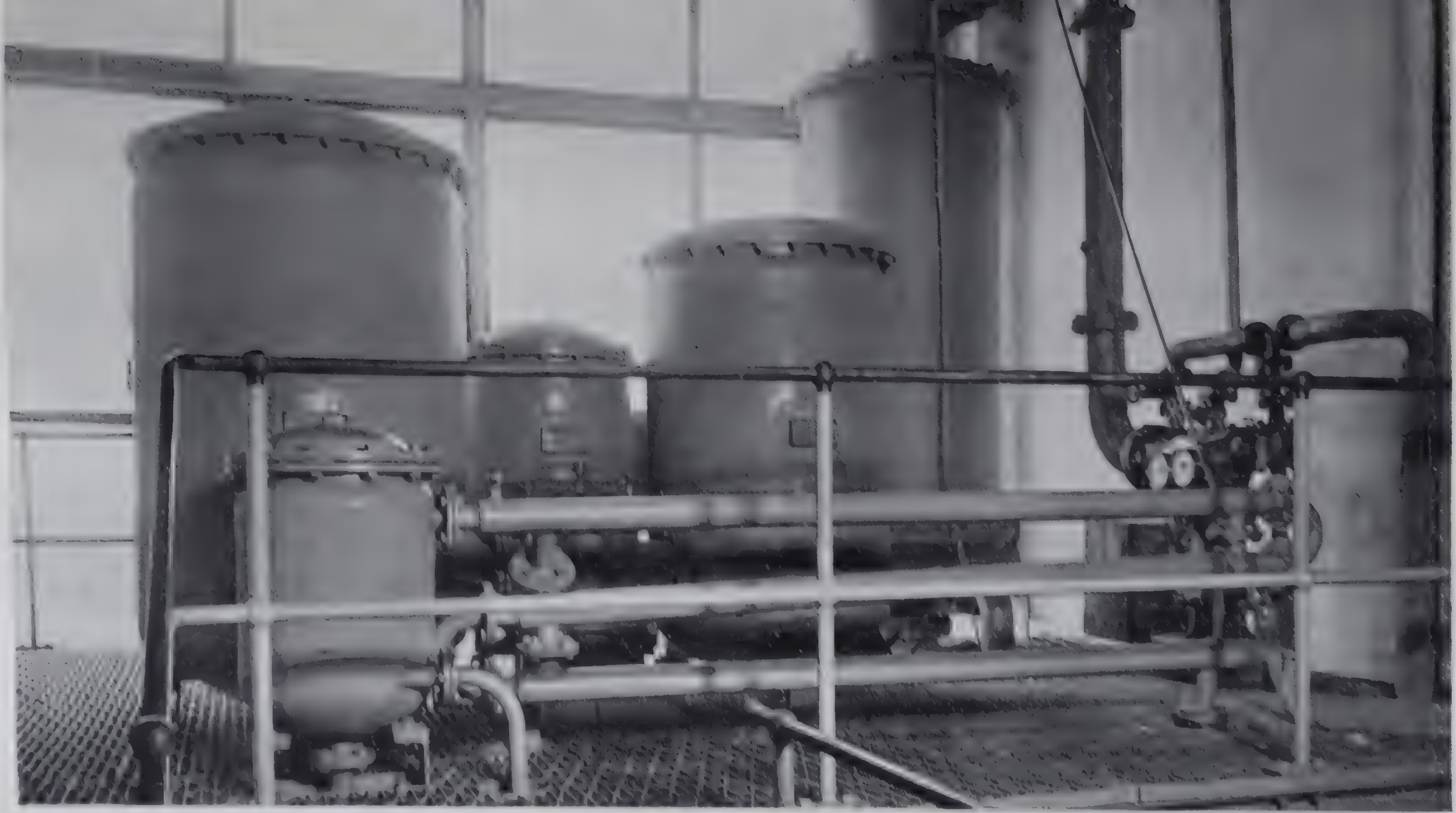


FIG. LXI. Kestner Climbing Film Evaporator for Apple and other Fruit Juices (separators for steam and volatile fractions)

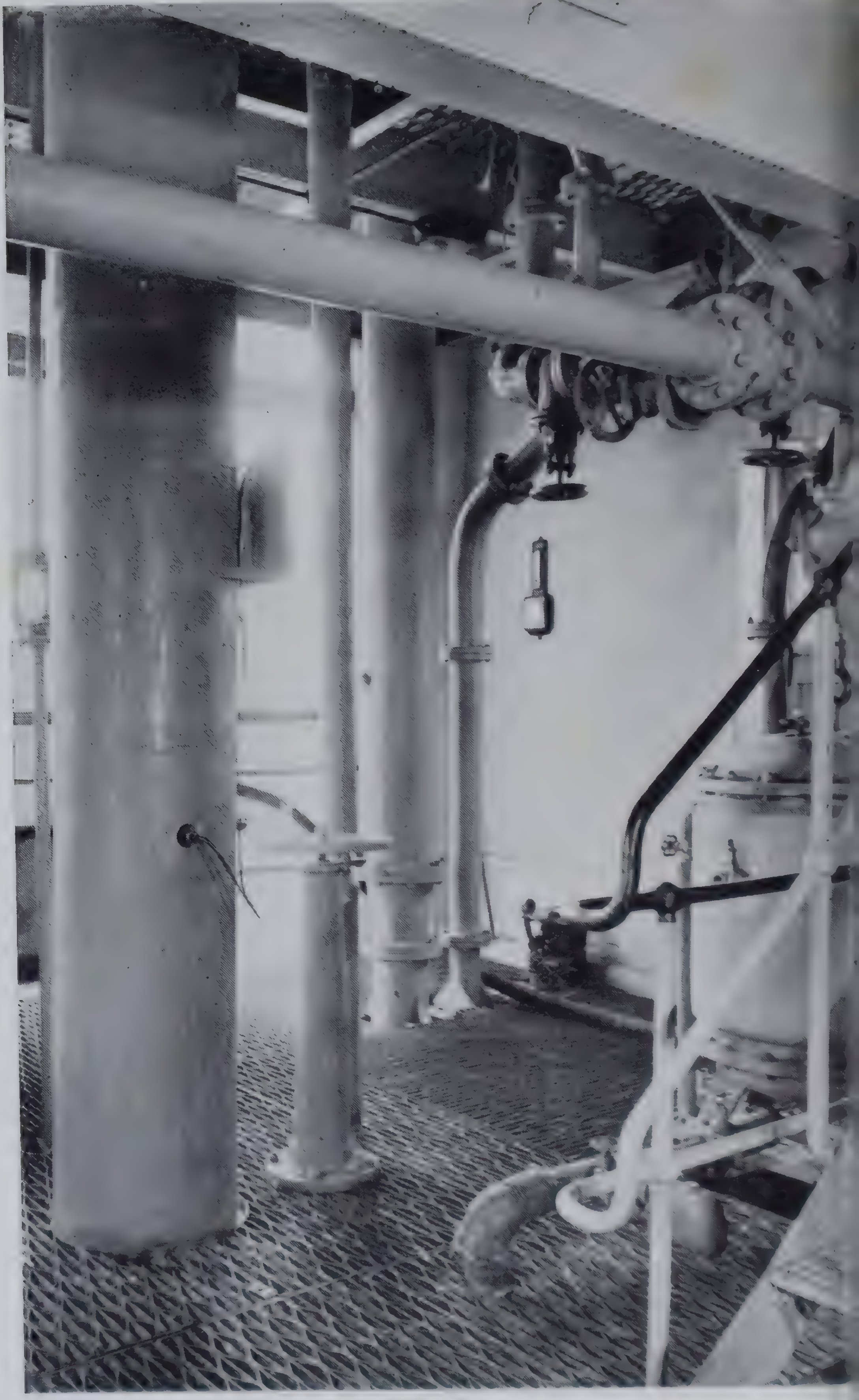


Fig. LXII. Kestner Climbing Film Evaporator (working platform)

in the bottle of about 5 atmospheres (75 lb.). (⅔ oz. sugar
gallon provides approximately 15 lb. pressure.)

he yeast starter is made from 2 lb. of a cider yeast which is
wn to form a compact deposit, or 2 lb. of Champagne yeast.
s is mixed with ½-gallon sugar syrup, ¾-oz. ammonium phos-
te and the mixture made up to 10 gallons of cider.

) *Fermentation.*—The cider, when these additions have been
pleted, should be bottled in champagne bottles, closed with
cial corks, driven 1½ inches into the neck of the bottle, and
ing 1 inch of the cork remaining outside. The corks are
l with special clasps or wires.

he bottles are then laid on their sides whilst the fermentation
cess proceeds. This may extend over one month at 18°C., or
months at 15°C. After this stage, the bottles are taken to
cellar and placed in special frames (pupitres), the necks
ng placed in the downwards position. The bottles are shaken
ttle each day to move the deposit gently down towards the
k—a process which takes one or two months.

d) *Disgorging.*—The deposit is removed from the bottle by
noving the cork with the neck facing downwards. This opera-
n should be the responsibility of a skilled workman, so that
loss of liquid may occur. When the deposit has been removed,
bottles are temporarily closed with conical corks and placed
a platform in a slightly inclined position.

e) *Final Adjustment.*—The bottles after being disgorged are
ally treated with a syrup composed of cider, alcohol, cane
ar and sometimes citric acid. The alcohol should contribute
, to the total alcohol of the product. This addition is intended
h to render the product more alcoholic and to inhibit any
ther yeast development. The sugar is needed to provide a
eet, smooth product; it should be added to suit the particular
te of the clientele for whom the cider has been produced. In
neral, the addition will be between 3-13 oz. per gallon of
er.

(*f*) *Preparation for Sale.*—The bottles are finally corked and
elled with the utmost care. The corks are wired in by one of
accepted methods and covered with some form of capsule.

Closed Cuvée Process

The authentic champagne process calls for a considerable stock of bottles and is exceedingly time-consuming and expensive on labour charges and storage space. An alternative, however, is available. It is known as the 'closed cuvée' system, and is in effect the fermentation of the cider in a large vat, 220-550 gallons in size, the vat and its contents being treated in every way as if it were a gigantic champagne bottle. The use of this closed vessel enables various specialised types of fermentation to be achieved, the use of low temperatures, the cooling or warming of the cider, pasteurisation of the product, fining of the cider in bulk, and its final filling into champagne bottles.

Champagne Ciders

If French cider-makers hope to compete with foreign interests, the production of naturally conditioned ciders by champagne yeasts is to be recommended as one of the most likely ways of developing a large export trade.

Certain cider-makers do not base their processing on dry ciders. On the contrary, they prefer to bottle ciders with a natural gravity of 1·018 and which are still fermenting. They add no yeast to the bottled product at the appropriate moment for inducing the secondary fermentation, unless they have reason to anticipate an excessively slow yeast action in the bottles. Other factories, however, operate the exact method employed in the Champagne area. Before the cider is primed preparatory to being bottled, it is carefully cleared by fining, tannin treatment or filtration, according to the German technique. Warcollier does not advise this treatment for the home market except in those cases where very pale and brilliantly clear ciders of the German type are desired. Such ciders as these do not find general acceptance in France and are suitable only for export. The only economic way in which this could be accomplished would be for production to be undertaken by a number of large factories, each dealing with a very considerable number of bottles so that the operating and overhead costs would be relatively low. At a Conference in 1917 on the subject of varieties of apples used in Germany and other European countries (except France) with a view to their introduction and use in France for champagne cider production, Warcollier indicated that certain medium-sharp fruits were particularly suitable for this purpose.

Warcollier, in various visits to other countries to inspect the national cider industries, made several interesting observations on the bottling of sparkling cider in Germany, England and Spain. These have been published in the following series of articles: 'German ciders' (*le Cidre et le Poiré*, Aug./Sept./Oct. 1912); 'Les cidres allemands en bouteilles'. 'Les espagnols' (brochure privately printed by the author); 'The manufacture of cider in England' (*Bulletin mensuel de l'office de renseignements agricoles*, January/July 1916 and August/September 1916).

In 1912, Germany exported to all parts of the world more than twenty million bottles labelled 'Champagne' which were a mixture of many varieties of sparkling beverages. In 1928, the world market was freed from such pseudo-wines, leaving the door wide open for genuine products to be marketed over a wide area. Serious competition with French products could be expected from Spanish, and above all, English ciders, which in the years before 1928 had been developed to a remarkable extent and had been exported in very large quantities.

Simplified Method for Sparkling Ciders

Smaller factories which cannot attempt to encompass the complete champagne process for cider-making should make use of the method described previously for the bottling of naturally matured ciders (p. 192). If clear ciders made by Warcollier's low temperature fermentation method are available, they may be bottled and put neck downwards for 6-12 days immediately after being filled, and the ciders will develop into sparkling products with fine aromas and no appreciable amounts of deposit.

Special Carbonated Ciders

According to the French regulation of 24th September 1933, ciders whose effervescence is due entirely or partially to the incorporation of carbon dioxide must be declared as 'cidres mousseux de fantasie' or 'cidres gazéifiés' or 'cidres gazeux'. They are prepared by the carbonation of clear, filtered ciders with specific gravities between 1·010-1·035 according to the degree of sweetening required.

Warcollier's special method of fermentation enables ciders to be produced in a condition which is eminently suitable for treatment in this way. These carbonated ciders have a shorter life than champagne type ciders and are, to this extent, their inferior; but they are nevertheless excellent beverages and can be produced at a reasonable price.

The German cider industry produced four-fifths of its total output of bottled ciders by the artificial carbonation method. Two or three-year-old ciders are generally preferred and these are treated with sugar and alcohol at the time of bottling. Carbonation is usually operated at a pressure of 55-70 lb./sq. in. The machines used for carbonation are of very different construction but are chiefly made on the reciprocating or reversible principle. Carbonated ciders in Germany are produced only by the large factories.

In England in 1928, both the commercial installations and the smaller factories (such as certain farm cider-makers) had developed the bottling of sparkling cider beverages. The usual pressure of carbonation is 12-20 lb./sq. in. and consequently there is little need for the use of champagne bottles. One-year- or two-year-old sweet or dry ciders are used and these are carbonated in special machines. The ciders are carefully filtered, preferably through cotton pulp, and the gas is often incorporated into liquors previously cooled to about 0°C.

In Spain, the Asturian ciders are produced in a similar way to the German products, the same type of apparatus often being employed.

French Carbonated Ciders

(*a*) *Choice of Raw Material.*—A clean, full bodied, clear cider with a fresh taste and aroma should be chosen. It is undesirable to choose ciders of mediocre quality, for artificial aeration will accentuate simultaneously their negative as well as their positive qualities. Many of the failures that have been encountered in this particular phase of cider production can be traced to the lack of care in choosing the basic material and such ciders, after carbonation, can only lose rather than gain the acceptance of the consuming public.

A further point of great importance is to utilise only stable ciders, by which is meant those that have already deposited all materials that are liable to be precipitated or coagulated under the further treatments to which they will be subjected. They should retain only a minimum of nutrients for the yeasts so that a renewal of fermentation is not to be feared. For this reason, ciders that have been made for two years are best suited for this form of bottling. It should be unnecessary to add that the ciders that conform best to this process are those made by Warcollier's special method, for they retain only minute amounts of nitrogen and are substantially free from yeasts and bacteria, and are characterised by their extremely fruity aroma and flavour.

(*b*) *Incorporation of Gas.*—A cider is to be considered well aerated when it contains such a quantity of carbon dioxide that the product, on being poured into a glass, retains the necessary sparkle and head for the required period of time. It is well known that the two essential factors in this connexion are a low temperature and an extremely fine state of division of the dissolved gas in the cider. Carbonating machines should thus achieve the maximum possible impregnation of the cider with the carbon dioxide. It is also known that for adequate carbon dioxide retention, the cider should possess certain viscous qualities which are conferred by colloidal substances such as pectins and gums, as well as by a high alcohol content. The bubbles of carbon dioxide must remain in an exceedingly minute condition, and this is achieved to some extent by their adsorption on the surface of the colloidal constituents of the cider.

Carbonation by means of liquid carbon dioxide is increasingly used. The gas is supplied in steel cylinders under a pressure of 50-60 atmospheres. One litre of carbon dioxide weighs 1·97 gm. at normal temperature and pressure. At 15°C., a cylinder of 10 kg. gas provides about 5,100 litres of gas at atmospheric pressure.

Carbon dioxide is soluble in water and alcohol. Bunsen and Carius have prepared tables showing the solubility of carbon dioxide in water and alcohol at atmospheric pressure (Table XXII).

TABLE XXII.—SOLUBILITY OF CARBON DIOXIDE IN WATER AND ALCOHOL

Temperature °C.	CO_2 *absorbed by* 1 *litre water* litres	CO_2 *absorbed by* 1 *litre alcohol* litres
0	1·7967	4·3295
5	1·4497	3·8908
10	1·1847	3·5140
15	1·0020	3·1993
20	0·9014	2·9465

The data show that the amount of gas dissolved in wate alcohol decreases as the temperature rises. For this reason, desirable to carbonate the cider at a low temperature, for ci behaves like a dilute aqueous solution of alcohol, possessing an average a coefficient of absorption between 1·200 and 1· at 15°C. A litre of cider dissolves a little less carbon dioxide t a litre of water on account of the sugar and other solids in cider that reduce its coefficient of absorption. On the ot hand, it is scientifically capable of proof that the amoun carbon dioxide necessary to saturate a liquid is not exactly p portional to the pressure that it should exert. Thus, if volume of gas is needed to saturate one volume of cider atmospheric pressure, somewhat less than two volumes of would be needed to saturate the same cider to a pressure of atmospheres, and less than three volumes of carbon dioxid obtain three atmospheres pressure, and so on. Fig. LXV sh a French Kendall carbon dioxide saturating machine, by use of which accurately weighed quantities of carbon dio can be continuously passed into cider for bottling.

(*c*) *Artificial Carbonation in Bottles.*—Many types of appar exist for this purpose; i.e. Bel, Bobet, Trouillard et Cie., Cir Pavard, Durefort, Gérard, Guéret frères, Guyot, Le Grand Mercey, Pépin, Piot, Valléry, etc.

The most acceptable small plant is of the reversible type, being introduced into each individual bottle in such a way the cider is agitated to the minimum extent whilst the car dioxide is intimately incorporated in the beverage. Certain ty of machines enable continuous filling and aeration to be un taken.

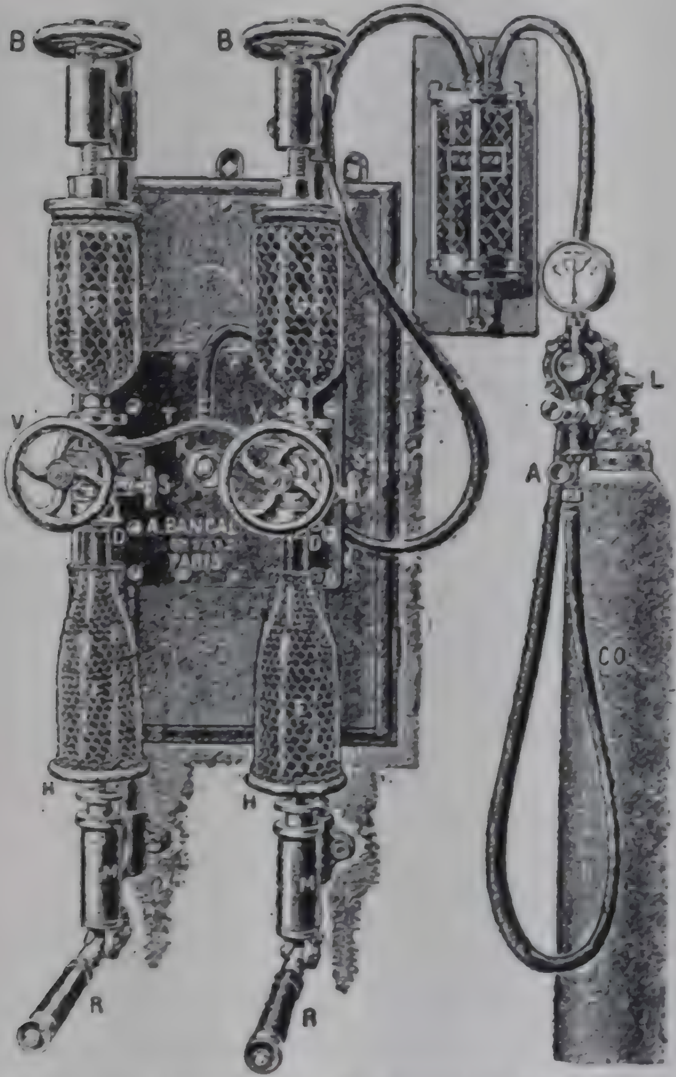
As a typical carbonating machine of this type, the Victori Automatique of Bancal-Quéru can be considered (Fig. LX All surfaces that come in contact with cider are lined with sil

The order of operation is as follows:

(i) The reducing valve on the carbon dioxide cylinde adjusted to the pressure required (40-70 lb./sq. in.).

(ii) The carbon dioxide is allowed to pass through the w ing apparatus and to flow into the two saturating vessels to remove the air from the bottle by opening the valves f few minutes.

(iii) The levers R are lowered and the filled bottles are pla



LXVI. Victorieux Automatic Carbonating Machine of Bancal-Quéru

he adjustable base plates H; by raising the levers again, the ks of the bottles are tightly pressed against the rubber hers D, so that no gas can escape.

iv) The apparatus is inverted by a semi-circular movement. this position, the bottles now occupy the place formerly en by the saturators G, and the liquid passes from the bottles the saturating vessels, thereby contacting the carbon dide gas and being saturated.

v) The apparatus is then returned to its original position: cider flowing back into the bottles and again being carnated with the gas.

vi) The bottles are removed. No gas is lost at this stage, h indicates how very intimately the gas is incorporated the cider.

Carbonated ciders are generally bottled in containers which are closed with metal capsules (crown corks or 'Dan' caps), or by a china closure similar to that used for beer. For export, such ciders should be filled into champagne bottles and closed with the correct type of champagne cork which has the well-known mushroom shape. The pressure is usually 75 lb. for export, but 20-30 lb. are sufficient for the home market, in which case mineral water bottles and metal closures are sufficient.

(*d*) *Continuous Carbonation of Ciders* (Large-scale production).—The Établissements Kendall introduced a chilling system for the bottling of cider which has very real advantages over any of the slower discontinuous methods that do not make use of low temperatures. The plant includes a complete refrigerating set, and provides accommodation for the alternate chilling and carbonating of ciders, thus arriving at a continuous bottling line. The two main vessels are immersed in brine. The success of the operations depends on the temperature of the carbonating vessel, the cooling time, the pressure of gas and the time taken to incorporate the gas into the cider.

When using this equipment, the priming liquors are added to the cider barrels before the product is pumped into the Kendall machines. The method is very satisfactory, for neither the cooling nor the filtration affect the sweetening of the cider. No sugar is retained by the filter and, in properly constituted ciders, the sugar content has no adverse effect on the filtration.

After the carbonation process, the cider is forced by air or carbon dioxide pressure through two special filters in series. Figs. LXVII and LXVIII show a modern Kendall filter and hydraulic press for the compression of the pulp. The insoluble materials precipitated by the cooling treatment are retained on the filter medium and, working at low temperatures, the useful life of a filter setting is greatly prolonged.

The pressure of gas is usually chosen between 15-30 lb. The incorporation of gas should be so perfect that a glass of cider should show a bead of bubbles half an hour after being poured out.

From the filter, the cider is filled through a counter pressure machine into bottles or casks. One man, provided he is a skilled workman, can operate the whole installation, but in any case only one extra operative would be needed.

Three sizes of plant are available, capable of 350, 700 or 1,000 gallons per day.

Ciders produced by this method have a very long life, probably on account of the removal by the filter of nutrients and micro-organisms and also because the cider is completely saturated with carbon dioxide. Warcollier has made an examination of ciders made by this method and has found them to be of uniformly excellent quality.

(*e*) *Cirier-Pavard Carbonating Plant.*—This machine is a complete unit for the carbonation of cider by the use of freezing. For filtration, the cylindrical barrel filters, packed with pulp, are preferred.

(*f*) *Quantity of Gas for Carbonation.*—The exact quantity of carbon dioxide needed for the carbonation of cider varies with the nature of the cider, the temperature of saturation and the pressure in the bottle. As a minimum, 22 lb. carbon dioxide will be needed for 550 gallons of cider.

Translator's Addenda

Closed Cuvée Systems

Warcollier refers to the possibility of promising developments for the closed cuvée system of producing naturally sparkling ciders. Certain processes have been developed in England, Canada, America and France and are the subject of the following brief descriptions.

(*a*) *Redox Process* (1).—This method of producing beer for bottling has been installed in a number of large breweries in Britain, the specialised plant being made by Geo. Adlam & Sons Ltd., of Bristol. The same type of plant has been used for cider production with the most promising results. Ciders have been produced which have perfect stability and which are characterised by remarkably vinous aromas and flavours. The basic principle involved is the reduction of oxygen in the product, and the process has been scientifically based on a consideration of the oxidation-reduction potential (rH) of the product under treatment. The sequence of processes to which the cider is subjected is carried out in the same vessel, and this prevents both the renewed infection and oxidation caused by constant transfer of the product from vessel to vessel.

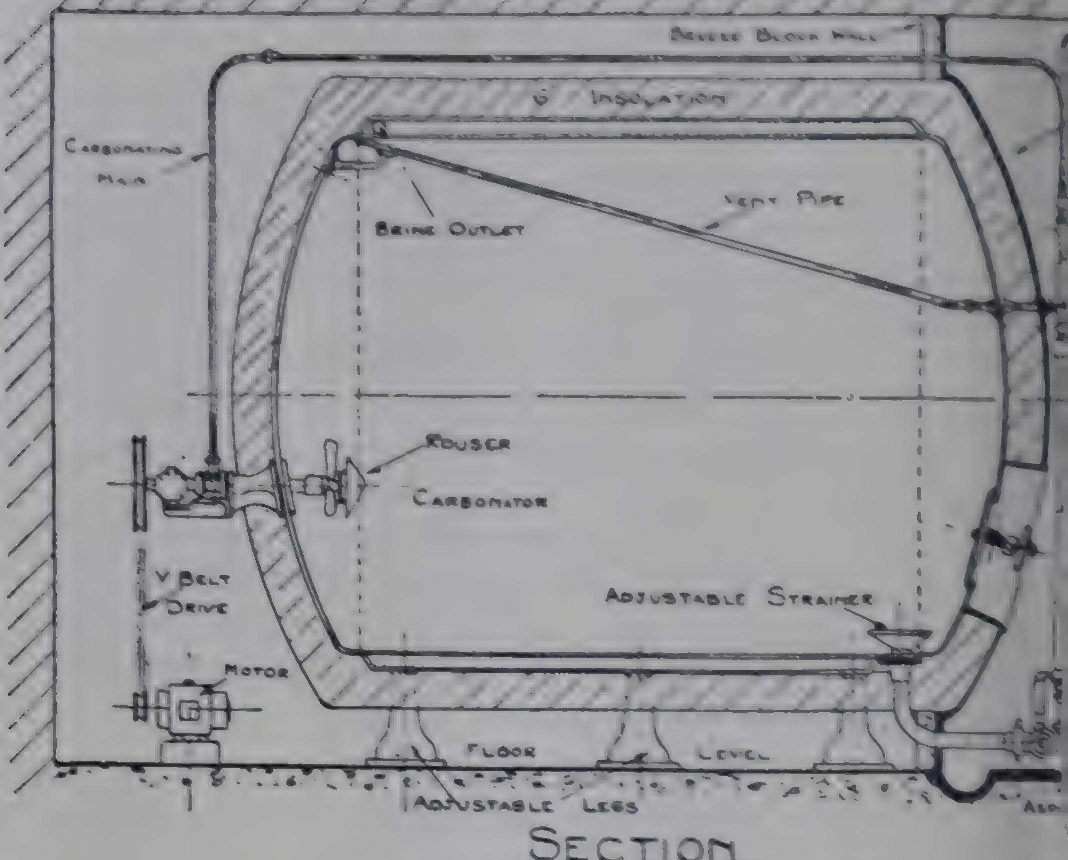

Breeze Block Wall
6" Insulation
Carbonating Main
Brine Outlet
Vent Pipe
Rouser
Carbonator
V Belt Drive
Adjustable Strainer
Motor
Floor Level
Adjustable Legs
Section.

FIG. LXX. Section of Redox Tank

The steel tanks are lined with glass enamel, Prodor-C stainless steel. They are surrounded by a brine jacket a whole then insulated with cork. Each such vessel has for venting or recovery of carbon dioxide, application pressure, rousing, carbonating and sampling. Any deg carbonation may be achieved or the product can be c with the carbon dioxide developed by its own fermen Figs. LXIX and LXX show a battery of Redox tanks drawing of a section of one such standard Redox tank.

(*b*) *Charmat Process* (2).—This procedure was originally duced for the quick production of champagne but is no being used in a limited but successful manner in France f quality cider production. The precise method of opera as follows:

The raw material consists of a naturally sweet cide sweetened dry cider. The material is pasteurised by a electrode in a steel glass-lined tank which is hermetically and is capable of withstanding a heavy pressure. A yea culum is then added and the temperature of the cider a ns of a thermostatically controlled electrode, so that the d degree of fermentation takes place in 7-10 days. The e rises during this time to 80 lb. per sq. in., and the dioxide gas is thoroughly impregnated into the liquor. ntation is stopped by passing a refrigerant through an al coil until the cider reaches a temperature just above ezing point, and is maintained at that temperature for ays, during which a very effective clarification occurs. upernatant liquor is then passed through a special filter isobarometric pressure. The filter possesses an interesting uction. A considerable number of woven cotton discs are l over a perforated stainless steel rod and pressed tightly ner by adjustable end pieces.

ly three or four weeks are needed for the complete process he products are naturally conditioned ciders, with a full, s character, whilst there is little fear of further deposit of iness. Fig. LXXI shows diagrammatically a series of tanks ich the various processes are effected in adjacent vessels.

Canadian Process.—Arengo-Jones (3) has given details on pplication of a closed cuvée method for Canadian ciders. main fermentation can be undertaken in wooden vats or e cuvée itself. If the former is the case, the cider is trans- d to the cuvée at a gravity of 10 points above that at which ntended finally to stabilise the cider. The author suggests the addition of 20% of fresh, enzymed, flash pasteurised mented apple juice to the cider after its final fermentation mpleted provides a remarkable fresh and characteristic e flavour to the cider. In some cases, pasteurisation of the ed, bottled cider is recommended.

r optimum quality, such ciders should contain 0·5-0·6% acidity, less than 0·08% volatile acidity and 0·10-0·15% nnin. The addition of a proportion of European cider apple improved the quality of the cider to an appreciable degree. addition of brandy to raise the alcohol content to 15% uced an apple wine of distinction.

) *American Process.*—A bulk process for sparkling cider has described by Tressler, Celmer and Beavens (4). The fer- tation process required only three days if accelerated by the tion of apple juice or concentrate, and ammonium mono- ogenphosphate. The optimum temperature for fermentation was found to be 21°C. A correctly constituted blend, fe mented in glass-lined pressure tanks, produced 90 lb. pressu per sq. in. in three to four days, and the chilling and bottlin process extended over only 24-36 hours.

English 'Champagne' Cider

Only limited quantities of ciders made by the original char pagne wine process are made and their production does n seem to be increasing. Their quality, however, is celebrat and these products represent the highest stage of achieveme in cider-making technique.

Bottling of Carbonated Ciders

Practically all carbonated cider is chilled before bottlin Photographs of English plant for chilling and bottling a shown in Figs. LXXII-LXXVI.

The bottling machine designed since the end of the last w by Bratby & Hinchliffe Ltd. is shown in Fig. LXXII. Th Bratby New Velvaspeed machine consists of a 36 head rota counter pressure filling unit and 8 head rotary crowner, th whole outfit being capable of dealing with 500 dozen bott per hour. The filling head is of novel construction, with joir and valves of simple rubber seatings which avoid some of t possible disadvantages of a plug type filling head. Machines this type operate up to pressures of 75 lb. per sq. in., th enabling cider to be bottled in a highly carbonated conditi even though there may be a temporary rise in temperatu The whole operation of counter pressure filling and snifting carried out by the reciprocating motion of the bottle automa cally fed to the machine. Each filling head is a complete un in itself.

Fig. LXXIII illustrates a chilling and carbonating unit the Pontifex type.

The Pontifex 'W' Size 'Perfection' Chiller and Carbonat consists of two or more copper-tin lined carbonating cylinde contained in a mild steel tank into which the cider is transferr from barrel or tank and is chilled. This chilling is effected spraying brine drawn from the shell and tube cooler inco porated in the refrigeration plant in the outside of the cylinde The chilling process is accelerated by the rotation of paddles cylinders, whilst the agitation thus effected also assists in carbonation of the cider to any required degree. A feature he plant is that both the air lines and the cider mains are arranged that the complete procedure is continuous; thus, ing, chilling and carbonating can be carried out coincident th filtering and bottling.

Fig. LXXIV depicts a 36 head bottle filling machine of odern type developed by the firm of H. Pontifex & Sons Ltd. he machine is designed on the rotary counter pressure prin- ple and is arranged to take clean bottles from the washing achine and deliver them to the crown corking or stoppering achine entirely automatically. The movement of bottles is tuated by air pressure. The automatic feed machine is so djusted that any bottle which becomes jammed is rejected and e machine brought to rest.

Another type of cooler for cider is being operated at the bbotskerswell factory of Messrs. H. Whiteway & Sons Ltd. nd owes its design to the York Shipley Company (Fig. LXXV). he machine shown in the illustration is used for the cooling of der for bulk carbonation. The plant is arranged to cool brine – 5°C. and its capacity is equivalent to the cooling of 600 allons of cider per hour from 21°C. to – 1°C. The machine is omposed of a 40 h.p. twin cylinder ammonia compressor with ell and tube type condenser and submerged steel pipe evapo- ator in the brine tank. The brine is picked up by a centrifugal ump and passed through the cider coolers, absorbing the heat om the product before returning to the tank for recooling and ecirculation.

For smaller scale work, the Clayton Quieta carbonator and ller (Fig. LXXVI) is remarkably efficient and has been of the reatest value to the English cider-making industry.

REFERENCES

(1) Dixon, B., *J. Incorporated Brewers Guild*, May 1939.
(2) Charley, V. L. S., *Ann. Repl. Long Ashton Res. Sta.*, 1937, p. 160.
(3) Arengo-Jones, R. W., *Fruit Prod. Jour.*, 20(10): 300-3, 321: 1941.
(4) Tressler, D. K., Celmer, R. F. and Beavens, E. A., *Ind. and Eng. Chem.* (*Ind.*), 33(8): 1027-31: 1941.

CHAPTER XIX

OLD CIDERS AND SPECIAL BEVERAGES FOR THE FARM

SOME advice may usefully be given to farm cider-maker abling them to produce, in years of shortage, palatable c from stocks made in previous seasons when there was an dance of fruit.

These ciders will generally be dry, and the simplest m is to sweeten them with sugar syrup. After a few days, a fermentation will ensue, and the cider will develop som An addition of ½ to 1 lb. of sugar per 10 gallons should be cient for this purpose.

If the cider is slightly acetic, fermentation may not spontaneously. A special culture of yeast should then be a If apple juice is not available for the growth of a yeast st a solution of 1 lb. of sugar, ⅓ oz. tartaric acid and 5 gm monium phosphate is made up in 1 gallon of water an yeast added.

Cider in full fermentation (4½ gallons to 100 gallons of to be treated) can be used instead of a pure yeast cu 4½ gallons of actively fermenting cider are placed in a barrel, to which are added 10-15 gallons of cider hea 20°-25°C.; the next day, a further 20 gallons of cider are and the cask completely filled one or two days later. method ensures the best conditions for yeast fermentat

Some ciders can be considerably diluted for consumpti the farm. A cider with 6% alcohol, increased to three ti volume, will then possess only 2% alcohol. If it is desire the alcohol content should be higher, then sugar can be to the required degree. Should it be necessary to raise the hol by 1% by weight, then 23 lb. of sugar should be adde 100 gallons of the diluted cider. To each 100 gallons of the should be added 7½ oz. tartaric acid, 3 oz. of cachou ta 3 oz. of ammonium phosphate and a little caramel or ch

A sparkling drink can be made by adding a yeast starter s described in the preceding case.

beverages cannot be sold; they are only intended for the farm.

Dried Apple Beverages ('boissons de pommes seches')

designation is reserved entirely for beverages made from apples.

first article of the Regulations of 24th September 1933, g with the application of the law of 1st August 1905 on pression of frauds, lays down that 'cider' is the appelation ed for beverages made from fresh apples or fresh apples ears, extracted with or without the addition of potable , whilst 'boisson de pommes seches' is the term reserved verages produced from dried apples. Further, according law of 6th April 1897, such drinks should not possess more 2·4% of total alcohol by weight.

Preparation of 'boisson de pommes seches'

gnon, in 1892, compiled a note on this subject. He recom- ed the extraction of the dried fruit in an open barrel fur- d with a false bottom. The dried fruit and water is allowed acerate for 12 hours, when the liquor is withdrawn and the ction repeated thrice. The process is most satisfactorily ved by using a battery of extraction vessels, similar to the sers for obtaining juice from fresh apples. The fruit material be pressed finally to remove the last useful quantities of . The combined extracts are then fermented by one of the pted methods (the use of 7½ oz. of yeast per 100 gallons is ssary). Various other formulae have been advocated for the aration of these drinks.

The juice from dried apples can be obtained by adopting procedure of pressing and re-soaking. 120-140 lb. dried e are macerated with 33 gallons water for 12 hours. The is pressed and the residue macerated with 33 gallons of r for 8 hours. Again, the mass is pressed and the whole ess repeated, with ultimate inoculation with yeast of the bined pressings (100 gallons).

i) Truelle gives the following recipe for 100 gallons of drink:

Dried apples	120 lb.
Tartaric acid	15 oz.
Yeast -	15 oz.
Caramel -	to correct colour
Water -	to 100 gallons

The apple material is boiled for half an hour with 60 gallons of water, and the concoction is mixed with the other ingredients, plus yeast, in a cask and allowed to ferment. In this formula, one can replace a certain quantity of apples by sugar. (It is useful to recall that 23 lb. sugar dissolved in 100 gallons will produce 1% alcohol by weight.)

(iii) This method is employed by certain makers in Havre. 40 lb. dried apples, 10 lb. of sugar, 12 gallons of ordinary cider are mixed in a barrel and made up to 100 gallons. Fermentation will start automatically.

(iv) 60 lb. of apple material, 20 lb. sugar, 7½ oz. tartaric acid, 1½ oz. ammonium phosphate, 7½ oz. yeast and caramel to colour the drink are used. The apples are boiled for 10 minutes in five times their weight of water. The extract, together with the other materials, is mixed in a cask, brought to 100 gallons and fermented.

Composition of Dried Apples

100 lb. of fresh apples produce about 25 lb. of the dried product containing 20% of moisture. The dried material will contain 40-50% sugar, so that in order to produce a beverage with 2·4% alcohol by weight, it is necessary to employ 100-130 lb. per 100 gallons of fruit material.

The best type of fruit to use for this purpose possesses a medium acidity, such as American exported fruit. Sweet and bittersweet fruits, after being dried, provide extracts that clear only with difficulty and if they must be used, tartaric acid should be added to avoid this.

CHAPTER XX

DISORDERS OF CIDER

DURING the manufacture and storage of ciders, the raw materials and finished products are subjected to numerous changes in composition, many of which are due to the presence of living organisms. Ciders are especially susceptible to microbiological changes on account of their low alcohol content (3·0-6·0% by weight), and their relatively high content of solids. Such materials as sugar, pectins, gums, malic acid, glycerine and potassium salts can behave as nutrients for micro-organisms which gain access to the cider.

Ciders are protected against such organisms by their natural tannins, and, to a lesser extent, by their malic acid, whilst the poverty of the medium in nitrogen also is a contributing factor.

The only effective measures against the development of disorders in ciders are those recommended in the preceding pages for harvesting the fruit, and the manipulation of the juices and fermented ciders.

It is naturally better to seek at all stages of the processing to prevent the inoculation of the cider by the organisms responsible for disorders than to omit the necessary precautions and subsequently be forced to take active measures to prevent their development. The curative treatments are seldom permanent in effect and can rarely be applied without adversely affecting the quality of the cider.

Disorders can be classified in three categories:

I. Disorders due to aerobic organisms - - - -	*Mycoderma vini* (*la fleur*) Acetification (*la piqûre* or *acescense*)
II. Disorders due to anaerobic organisms - - - -	Ropiness (*la graisse*) Sickness (*la tourne* or *la pousse*) *'l'amertume'*, *'la mannite'*
III. Disorders due to oxidase or chemical action	Blackening Green colouration Odour of rotten eggs

Mycoderma vini

This is a bacterial disorder due to oval-shaped organis rather similar in appearance to yeasts, which develop at t surface of the cider forming a white, corrugated film (F LXXVII). The disorder is especially prevalent when ciders a left in contact with air.

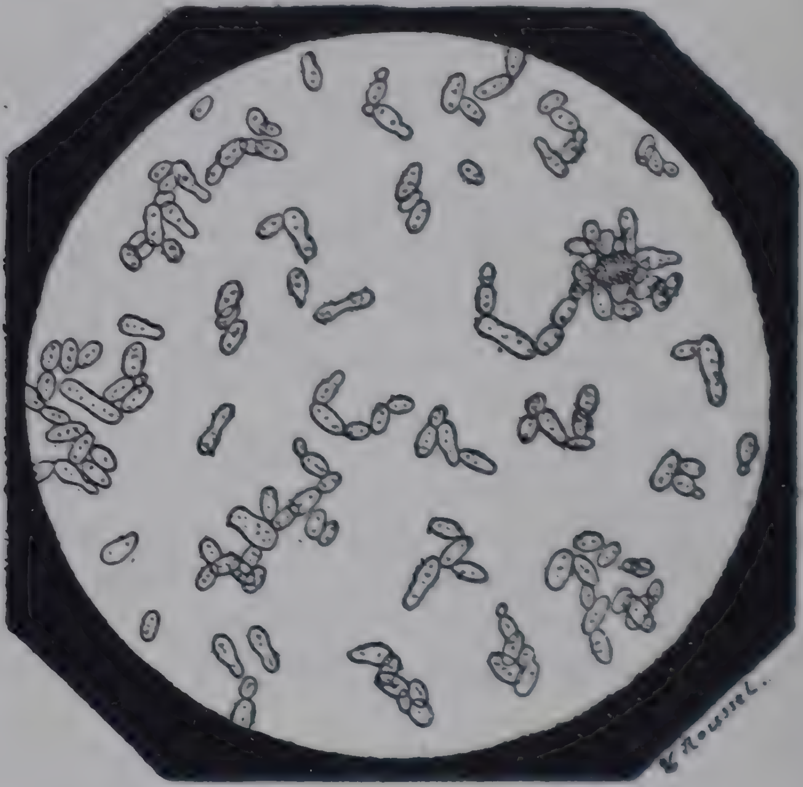


FIG. LXXVII. Mycoderma vini

The organisms convert the alcohol into water and carb dioxide, and the colour, bouquet and aroma of the cide destroyed, the ciders becoming flat and pale in colour. T chemical formula for the reaction is shown below:

$$C_2H_5OH + 3\ O_2 = 2\ CO_2 + 3\ H_2O$$

Preventive Treatment.—Air contact with the cider must avoided at all costs. Where ciders must be left in partially fil casks, the appropriate treatment must be applied; i.e. addit of sugar to maintain slow fermentation; use of a layer of para oil or carbon dioxide, or lining the casks with paraffin. Gener speaking, this disorder is not very dangerous, for the car dioxide gas evolved as a direct result of the action of the org isms on the alcohol forms a layer of gas over the cider and t itself inhibits further growth of the bacteria.

ative Treatment.—Ciders which have been attacked by derma should be re-fermented or blended with sound pro-. The film which is so characteristic of the disorder can be ved by filling the cask and allowing the liquor and the ined film to flow gently away.

Acetification

his is the most widespread disorder which affects cider. causal organism is *Bacterium aceti*, formerly known as *Myco-* *a aceti* or vinegar ferment.

very considerable number of varieties of acetic organisms known, but they are all characterised by the production of eyish-white film of a velvet consistency. This film develops well-known wrinkled appearance, eventually becoming h and glistening. Its constituent parts are oily and difficult noisten.

he film is composed of masses of tangled filaments of minute shaped organisms of $1{\cdot}5\mu$ diameter (Fig. LXXVIII).

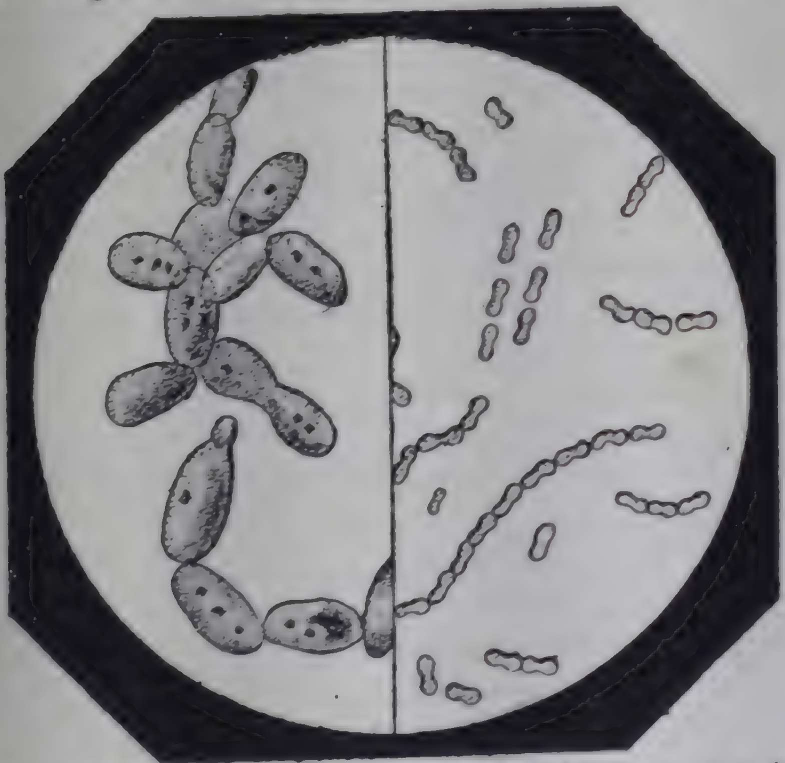


Fig. LXXVIII. Acetic Bacteria (Mycoderma aceti on left and Mycoderma vini on right)

The acetic bacteria convert the alcohol into acetic acid and ter by a process of direct oxidation as shown by the following mula: $C_2H_5OH + O_2 = CH_3COOH + H_2O$

On some occasions, when the oxygen is in limited supply, the oxidation is taken to a lower stage, with the formation of aldehyde:

$$2\ C_2H_5OH + O_2 = CH_3.CHO + H_2O$$

On the completion of the destruction of alcohol, the acetic acid itself is attacked and decomposed into carbon dioxide and water

$$CH_3COOH + 2\ O_2 = 2\ CO_2 + 2\ H_2O$$

The incidence of the disorder can be discerned by the taste when the cider contains 0·15-0·20% of acetic acid. Ciders containing 0·3% or more of acetic acid are unsuitable for consumption.

The development of the acetic bacteria is facilitated by the use of unsound fruit, unsuitable water, too long maceration in contact with air, and too extensive and protracted rebuildin of cheeses. The formation of a white head, a sign of an unsatisfactory defecation, is also a contributory factor to acetification

Baragiola has studied the destruction of malic acid by acetifying bacteria.

Preventive Treatment.—The only way to avoid acetification in ciders is to work throughout the processing in a hygienic manner, and prevent air access as much as possible. The cider should be stored at low temperatures and in lightly sulphure casks. All the instructions that have previously been given regarding the general treatment of ciders when in partially ful casks must be applied to all ciders if acetic taints are to b avoided.

Curative Treatment.—There is no permanent cure for acetification. It is possible to remove the acetic taste almost completel so that the cider becomes drinkable, but the bacteria will continue to develop and produce more acetic acid. Ciders shoulc therefore, be consumed immediately after curative treatment.

The hard taste can be removed by potassium carbonate. Th salt is dissolved in water and stirred into the cider with agitatior The precise amount to use must in every case be determined b trial with small samples, taking great care that the potassiur carbonate addition is not taken so far as to cause darkening o an unpleasant taste. In no case should the salt be added i excess of 3 lb. per 100 gallons. It is also possible to use causti potash for this purpose.

Immediately after this treatment, the cider should be racke

o a sulphured cask which should be completely filled. It is
en a good plan to attempt to induce a slow fermentation in
cider by the addition of 5 lb. sugar, 3 oz. ammonium phos-
ate and a little yeast per 100 gallons, and proceeding as
commended in the chapter on '*Boissons de pommes seches*'.

It is not possible to calculate from the acetic acid content of
cider how much potassium carbonate to add, for the greater
rt of the potassium will combine with the fixed acids in the
der (particularly malic acid) so that rather more potassium
rbonate is needed when the cider is in the high acid class.
he use of neutral potassium tartrate at the rate of 1-4 lb. per
o gallons is not recommended by Warcollier. In all his ex-
eriments the use of this particular salt had practically no effect
the taste.

Warcollier strongly disapproves of the use of bismuth sub-
trate, a procedure advised by Dufour and Daniel.

Ciders that have been treated for the reduction in acidity
nnot be offered for sale in France (Law of 24th September
933) and in consequence such beverages can only be consumed
n the farm or at the premises of the dealer.

Finally, ciders that are too acetic for normal curative meas-
res should be used for the production of vinegar.

Ropiness (*Oiliness*)

Ciders in bottles or casks that are attacked by this disorder
ecome viscous, and flow in a typically oily manner.

Microscopic examination of such ciders shows very long
urved chains of bacteria, composed of spherical cells of 1μ
iameter. Sometimes when the disorder is of long duration the
hains join together and no isolated cells can then be found.
There are a considerable number of organisms that are associ-
ted with this disorder (Fig. LXXIX, p. 278).

The bacteria are responsible for the formation of volatile
cids, alcohol, mannite and carbon dioxide, and of a mucila-
inous material of indefinite composition. The formation of all
hese compounds except the last mentioned are also connected
with the disorder known as 'sickness'.

Müller-Thurgau and Osterwalder showed that ropy ciders
ften contained malolactic organisms, especially *Bacterium gra-
cile*. According to these workers, ropiness can occur in com-
pletely dry ciders.

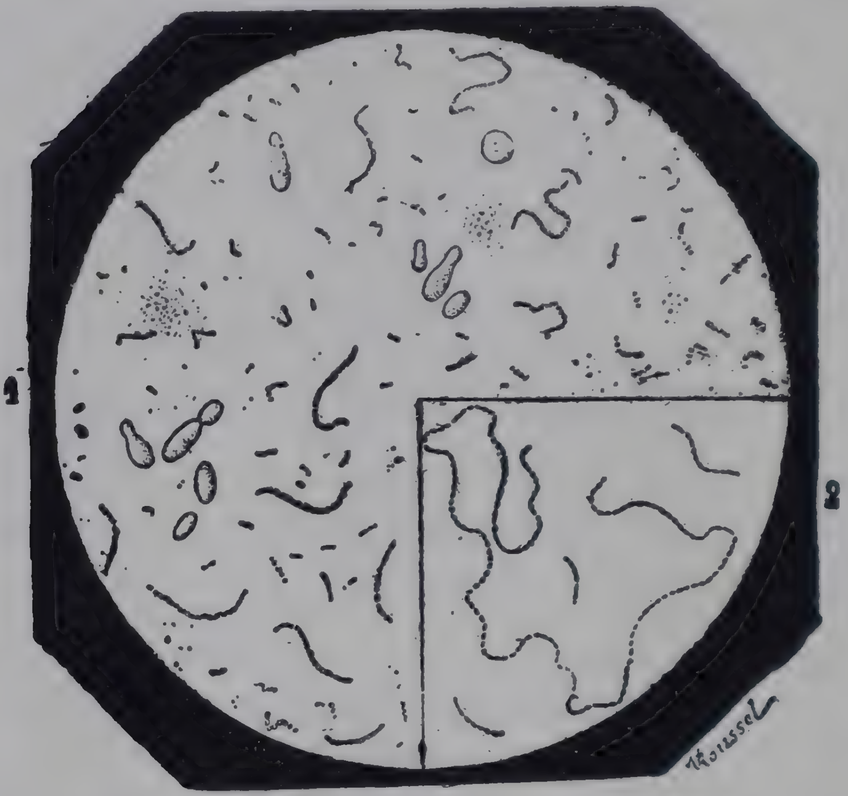


FIG. LXXIX. Ropiness Bacteria (appearance in Cider and (inset) in pure Culture)

Kayser has investigated several types of organisms which he has isolated from ropy ciders. The development of the causal organisms is facilitated by a complex system of aerobic and, above all, anaerobic conditions in the cider.

O. Grove has also studied this disorder.

Preventive Treatment.—The following measures should be adopted: cleanliness in all operations; use of fruit rich in tannin; complete removal of lees by a series of rackings; use of finings.

Curative Treatment.—Provided there is no danger of the cider blackening in the air, it can be violently agitated to destroy the viscous material responsible for the characteristic condition of the product. Warcollier has successfully centrifuged ciders in a supercentrifuge laboratory machine rotating at 36,000 r.p.m.

The most usual method is to fine the cider with 1½-2¼ oz. of tannin per 100 gallons followed by 1½ oz. powdered casein. Again, Spanish earth (1-3 lb. per 100 gallons) can be used. The cider which has been treated with any other materials should be violently agitated, and the cask then closed up, the cider being eventually racked. This treatment is not always effective and the disorder may occur again in the same cider.

Pasteurisation is probably the most effective way of dealing with the problem.

The ciders that have been subjected to the heating procedure lose their flavour and much of their value. They should be blended with other ciders and consumed at once: or they may be re-fermented (here, again, the fermentation is no guarantee that the disorder will not reappear). Ropy ciders can be distilled and provide normal eaux-de-vie.

Cider Sickness (*la tourne, la pousse, l'amertume*)

These disorders are still not clearly distinguishable one from the other. In one thing, however, they are similar, for they all appear to produce the same end-products, carbon dioxide, alcohol, volatile acids, mannite and lactic acid.

The disorder known in France as '*la pousse*' is characterised by the formation of carbon dioxide and volatile acids. Affected ciders contain rod-like organisms of 1μ diameter, very long and similar in appearance to those of wines suffering from the same disorder.

Barker and Hillier have undertaken a study of cider sickness. The disorder is due to an organism which in young cultures is found as rods 2μ long and 0·5μ wide, motile, isolated or grouped in couples; in old cultures, the cells are more elongated.

The organism causes the fermentation of the reducing sugars, with production of aldehydes (chiefly formaldehyde), ethyl and higher alcohols, oxalic, lactic, acetic and butyric acids, and carbon dioxide gas, together with a small proportion of hydrogen. Ciders with acidities below 0·3% malic acid are particularly liable to develop sickness, but acidities in excess of 0·9% are necessary to ensure complete safety from this disorder. Sickness does not develop at temperatures below 12°C., whilst the optimum temperature for the organism is 30°C.

Barker and Hillier give no curative treatment but advise the following as preventive measures: use of sound, clean fruit; blending of varieties to ensure juice acidities between 0·5-0·7%; rapid fermentation; storage of cider at low temperatures; and use of sulphur dioxide.

Grove recommends blending a sick cider with a high acid cider, the use of tartaric acid, or the addition of a mixture of malic acid and sodium chloride.

Müller-Thurgau and Osterwalder have shown that the deacidification of cider which may occur during fermentation may be the cause of the development of '*la pousse*'. Often '*la tourne*' is found subsequent to the loss of acidity, which explains how one can confuse the two disorders.

Andouard has described an organism causing '*l'amertume*' in ciders. Warcollier has also noticed in disordered ciders extremely fine filamentous organisms, 1μ in diameter, in the shape of rods placed end to end, and resembling the cells of the organisms in bitter wines (Fig. LXXX).

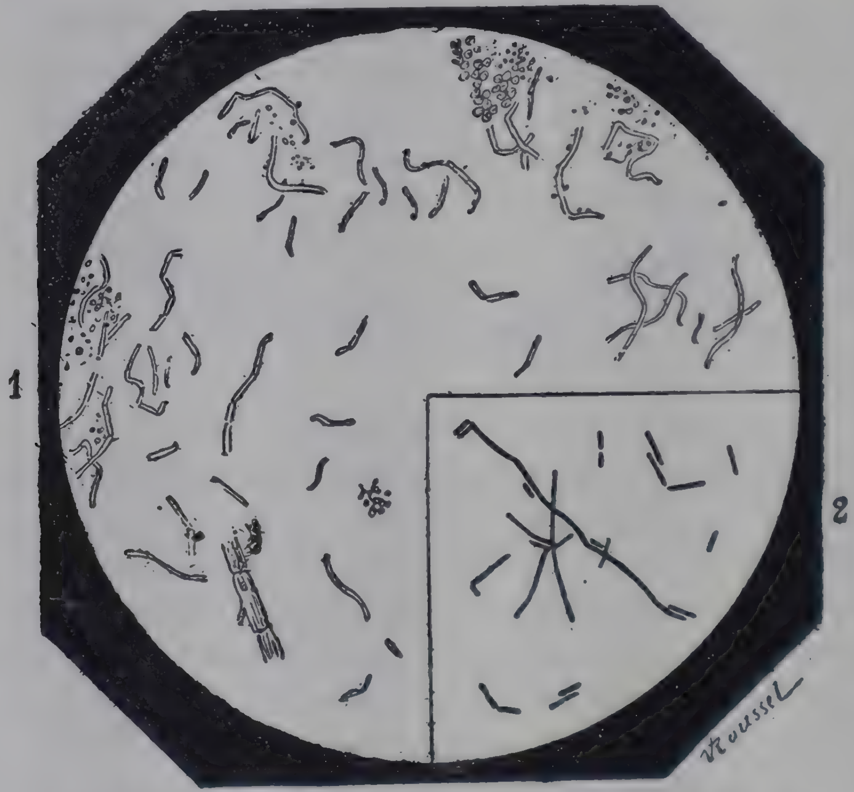


Fig. LXXX. Bacteria causing l'Amertume Disorder (appearance in Cider and (inset) in pure Culture)

Preventive Treatment.—The points which should be given special attention are the washing of the fruit, a sound keeving process, fermentation at low temperatures, storage under clean conditions, with repeated rackings, and maintenance of a suitable acidity.

Curative Treatment.—Sick ciders may be fined with tannin and casein, then racked into sulphured casks placed in well-ventilated and hygienic cellars. Such ciders should be used without delay, a slight amount of sugar being added, if necessary, to counteract the acidity.

Ciders which have developed an accentuated bitterness should be fined, sweetened and fermented with an active culture of cider yeast.

'Mannite' or Lactic Disorder

This disorder has been investigated by Müller-Thurgau and Osterwalder. The ciders contain mannite, lactic acid, carbon dioxide and acetic acid as a result of which the taste is seriously affected.

Sweet ciders are especially liable to be attacked; the organism mainly responsible is *Bacterium mannito pœum.* This bacterium has many resemblances to the sickness organism; laevulose and glucose are attacked and converted into lactic and acetic acids, carbon dioxide and mannite. Ciders that are attacked exhibit well defined acetic tastes. (This condition must not be confused with normal acetification.)

Affected ciders are often very high in extract, and in some cases the ciders become ropy.

The organisms responsible for this disorder do not develop in juices with acidities in excess of 0·6%, nor when the temperature is below 7°C. Between 8°-9°C., lactic and volatile acids are produced, but mannite is not observed until the temperature reaches 20°C. or over. 200 p.p.m. sulphur dioxide will inhibit the organisms, as will a very rapid fermentation.

The preventive and curative treatments are identical with those advised in the case of cider sickness.

Lactic Disorder in Fermented Ciders

This disorder resembles the previous one in most details, but there is no formation of mannite. Both lactic and acetic acids, however, are formed. In cases where the former acid is present in considerable proportions, the cider smells strongly of sauerkraut. Müller-Thurgau and Osterwalder have advanced evidence to show that the glycerin in cider can be converted into acidic products, such as propionic acid. There is also the possibility that other juice constituents, such as arabinose, may give rise to lactic and acetic acids. Some doubt exists regarding the nature of the responsible organisms.

Irregular Fermentation

Some factories where cleanliness and strict attention to hygiene is not constantly observed may encounter fermentations which produce butyric acid; the cider acquires an unpleasant taint and is quite unsuitable for sale. Such occurrences will never arise in an installation that is operated on correct lines.

Browning (*Brown Breakage*)

Following the pioneer investigations of G. Bertrand and Lindet, Dienert studied this problem and gave the following explanation of its occurrence:

Colourless tannin in the freshly expressed juice of the apple is converted by an oxidase system into an oxidised form of tannin giving to the cider its normal golden-brown colour. The oxidase, continuing its action, transforms all the colourless tannin into the normal oxidised form and finally into an even more oxidised state characterised by a deep brown colour, which is a feature of the disorder known as 'browning' or brown breakage of cider.

Dienert claims that a cider darkens more quickly when it contains relatively high proportions of oxidase and low amounts of tannin and acidity.

Warcollier, however, was led to the conclusion that the phenomena was not quite so simple as has been suggested above. He has indicated the presence of a peroxidase which is responsible for the formation of peroxides, compounds which are considered to be inevitably formed in any slow, steady, oxidation process affecting tannins. Warcollier made use of the previous studies of Bach, which showed that atmospheric oxygen combined with the colourless tannins through the agency of an oxygenase. Peroxides were formed as intermediates, and these compounds became even more fully oxidised, by the intervention of the peroxidase, into the brown compounds now being discussed. Thus, oxidases and peroxidases are responsible for two completely separate series of reactions. This hypothesis enables certain facts to be explained; i.e. ciders that have been heated almost to 100°C. will continue to darken, on account of the peroxidase recovering its activity several hours after the pasteurisation treatment. Oxygenase alone is inactivated permanently by the heat.

Blackening (Black Breakage)

Blackening of cider is due entirely to a chemical reaction. It can be caused directly by the addition of excessive amounts of chalk in the keeving process, or by storage of juice or cider in unlined cement tanks and vats. The acidity of the cider is neutralised by the calcium, magnesium and aluminium constituents of the cement, and the compounds formed by the metals and the fruit tannins dissolve in the cider and blacken as a result of contact with air. Blackening is more often the result of the combination of iron salts in the cider with the tannins, providing iron tannates which are identical with the black material used in the manufacture of ink, and which is prepared from oak galls and iron salts.

This disorder occurs chiefly in low acid ciders; high acidities retain the iron tannates in solution and the deterioration in colour does not occur.

In certain ciders the end of fermentation is characterised by a destruction of malic acid with the simultaneous evolution of carbon dioxide and formation of lactic acid. The cider will ultimately suffer an appreciable loss of total acidity and blackening will inevitably follow.

Preventive Treatments against Darkening and Blackening in Ciders.—The following points should be observed:

(*a*) Do not mill fruit that is rotten, under-ripe or covered with chalky soil.

(*b*) Do not allow the pulp or juice to remain in contact too long with the air.

(*c*) Avoid air contact during filtration or rackings.

(*d*) Do not use excessive amounts of fining agents.

(*e*) Carefully protect the juice from contact with cement or iron in any form.

(*f*) Add 100 p.p.m. sulphur dioxide to the juice as it leaves the press.

(*g*) When a certain blend of apples consistently gives rise to one or other of these disorders, the manufacturer should blend the fruit with other types to raise the acidity and tannin content, or else make some use of pears which will enhance the acidity without affecting the oxidase activity of the blend.

Curative Treatment for Discoloured Ciders.—To determine whether a cider is likely to darken in air it is merely necessary to expose it for 12 to 24 hours in an open bottle or glass. If darkening occurs, the following treatments should be tried out on some of the cider which has not already become dark.

(*a*) If the trouble has an enzyme origin, add 50 p.p.m. sulphur dioxide in the form of sulphurous acid or potassium bisulphite. The sulphur dioxide does not destroy the oxidases but merely inhibits their activities for a certain period. It must be remembered that free sulphur dioxide alone has any effect on this inhibition, and sufficient sulphur dioxide must be added to ensure that a certain proportion remains in a free state (the total amount added must naturally not exceed that allowable by law).

(*b*) If the discolouration has a chemical origin, the acidity should be raised by 0·05%. This is generally sufficient in itself to avoid the effects of a slight blackening of the cider. In more accentuated cases, attempts should be made to precipitate the tannates by adding 1¼-1½ oz. of casein per 100 gallons, followed by the removal of the deposit by racking.

Should the entire contents of a vat of cider have become black, the cider must be re-fermented after the addition of sugar, ammonium phosphate and a yeast starter; during the fermentation, the tannins or tannates will either become decolourised or be precipitated. The cider, having recovered its normal colour, should be immediately treated with sulphurous or citric acids.

Green Discolouration of Cider (Green Breakage)

This deterioration of cider is caused by the formation of certain green tannates of iron. These tannates are decomposed by tartaric or citric acids, and ciders suffering from this green colouration can often be restored to normal colour by adding 0·03-0·05% of either of these acids to the cider.

On some occasions, however, the action of these acids will not dissolve any green materials already precipitated. The tannates appear to be combined with pectic materials and to gain a certain stability therefrom. In other ciders, the salts of iron are present to such an excessive extent that the ciders cannot maintain them in solution, and the green colouration is produced.

Green colouration of cider can also be due to an enzyme action. Ferric sulphate behaves virtually as a peroxidase, and in the presence of highly oxidised forms of tannin, can lead to the appearance of the olive green colour. Ciders can be turned green merely by the addition of water containing dissolved oxygen and a ferric salt.

In 1944 Warcollier ('Study of the green colouration of ciders' *Comptes Rendus de l'Académie de sciences*, 30th March 1914) observed the effect of nitrites on the development of a green colour. The affected ciders contain nitrites; their colour is due to the combination of tannins, partially oxidised by the nitrites, with iron salts. The nitrites occur as a result of the reduction of nitrates either present in the water used for resoaking the pomace or occurring in the fruits themselves. Freshly produced pulp, left in contact with the air for a few minutes, contains appreciable amounts of nitrites.

Prevention of Green Colouration in Ciders.—The following precautions should be taken:

(*a*) Avoid excessive contact of juice with iron machinery or vessels; the mills should always be kept scrupulously clean.

(*b*) Avoid contact of cider with unlined cement vessels.

(*c*) Avoid use of water rich in nitrates; wash the fruit to remove earth and organic materials.

(*d*) Do not use under-ripe fruit, or apples grown on soils with high iron content; do not leave the pulp or juice in contact with the air. Adjust the acidity to a suitable figure and add 50 p.p.m. sulphur dioxide to the fresh juice.

Curative Treatment of Green Ciders.—The best treatment is to add citric or tartaric acids as advised for the previous disorder. If this is not effective, tannin should be added, accompanied by aeration of the cider. By this means, an intense green colour will be produced, but this can be precipitated by fining with isinglass or casein. Should neither of these treatments succeed, re-fermentation should be adopted. This procedure gives the most dependable results; the ciders become almost colourless and it is then necessary to add some permissible colouring substances.

The green colour in cider often accompanies the phenomenon of blackening. Laboratory investigation is necessary in these cases to determine the best treatment to employ.

Ciders that have been treated in any of these ways should be consumed after being blended with normal products, for the treatments also remove some of the flavour and character of the beverage.

Ciders with Odours of Rotten Eggs

Certain ciders develop an aroma reminiscent of rotten eggs or sulphuretted hydrogen. There are many reasons for this condition, but fundamentally it may be attributed to the presence of sulphur which gains access to the cider through the sulphuring of casks and the addition of sulphur dioxide compounds during the fermentation of the juice. Sulphuretted hydrogen is formed by the reducing action of the yeast during the fermentation process, sulphites being reduced to sulphides at the same time.

Care should be taken to avoid any sulphur falling to the bottom of the cask during the sulphuring operation. Should a cider have developed this objectionable aroma, it should be racked away from the lees which may still contain sulphur, and the hydrogen sulphide removed by the addition of sulphur dioxide; a deposit of elementary sulphur and water are formed. A fining or filtration process is then used to remove the sulphur and the cider is re-fermented or saturated with carbon dioxide.

CHAPTER XXI

ANALYSIS OF CIDER

Most of the methods to be described in this Chapter are those employed by the French Laboratories of the Department for the Suppression of Frauds. Certain non-official procedures are also detailed where their use has certain advantages.

The cider should be tasted immediately after opening the container. The colour and clarity of the product should be noted and special attention directed to the nature of any deposit in the cider. The deposit should be separated and examined under a microscope for the presence of yeasts, bacteria, acetic or sickness bacteria, etc.

Chemical Analysis

Specific Gravity (non-official):

(*a*) *Hydrometer.*—This method has been described on page 77.

(*b*) *Weighing-bottle.*—A weighing-bottle or other graduated vessel of known weight is filled with cider at the temperature marked on the particular vessel in use, and weighed. The weight of the cider in grams divided by the volume of the cider in millilitres provides an accurate figure for the specific gravity of the product.

Actual Alcohol (alcool acquis):

(*a*) *Distillation.*—A measured quantity of 200 ml. of cider at 15°C. is placed in the receiving vessel of a distillation apparatus connected with a condenser. The cider is neutralised with a little caustic soda, a few pieces of pumice stone are added and distillation is commenced. It is advisable to use a condenser with a sufficient cooling surface for the distillate to be collected as nearly as possible at 15°C. The distillate is led by a tube into a 200 ml. graduated flask until about two-thirds of the flask has been filled. The temperature is adjusted to 15°C. and the flask filled to the mark. The contents are well mixed and the temperature is determined and used to correct the figure obtained for alcohol by using an alcoholimeter.

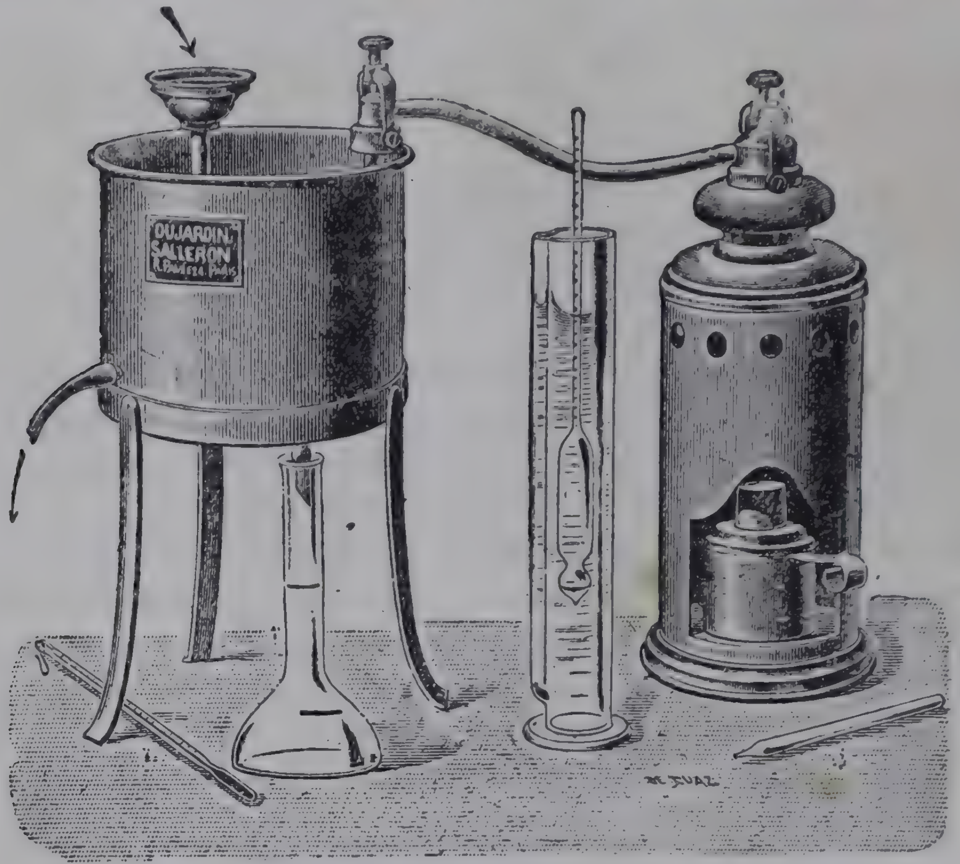


Fig. LXXXI. Dujardin-Salleron Apparatus

(*b*) *Dujardin-Salleron Apparatus* (non-official).—This apparatus (Fig. LXXXI) is widely used in France. It is composed of a metallic flask heated by some suitable burner. Attached to this vessel is a tin coil immersed in running water. The distillation and determination of alcohol content is carried out in the same way as for (*a*) above.

(*c*) *Dujardin-Salleron Ebulliometer* (non-official).—This apparatus is used especially for fully fermented ciders (Fig. LXXXII); the estimation is very quickly effected and numbers of determinations can be carried out in a short time, the results corresponding closely with those obtained by the distillation method.

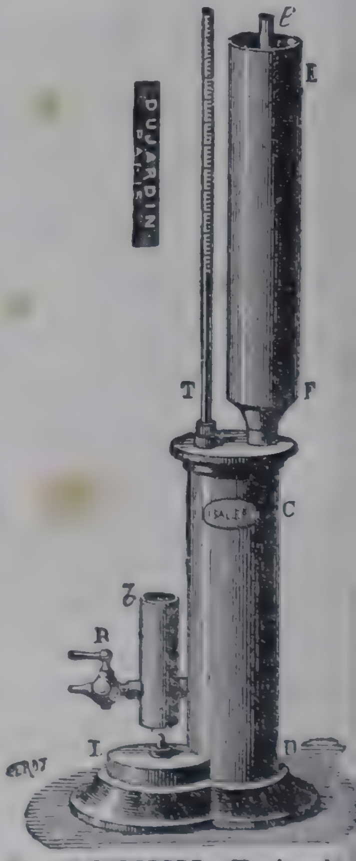


Fig. LXXXII. Dujard
Salleron Ebulliometer

Potential Alcohol (alcool en puissance)

(i) If a cider still retains some sugar, the total sugar content (calculated as glucose) should first be determined. The figure

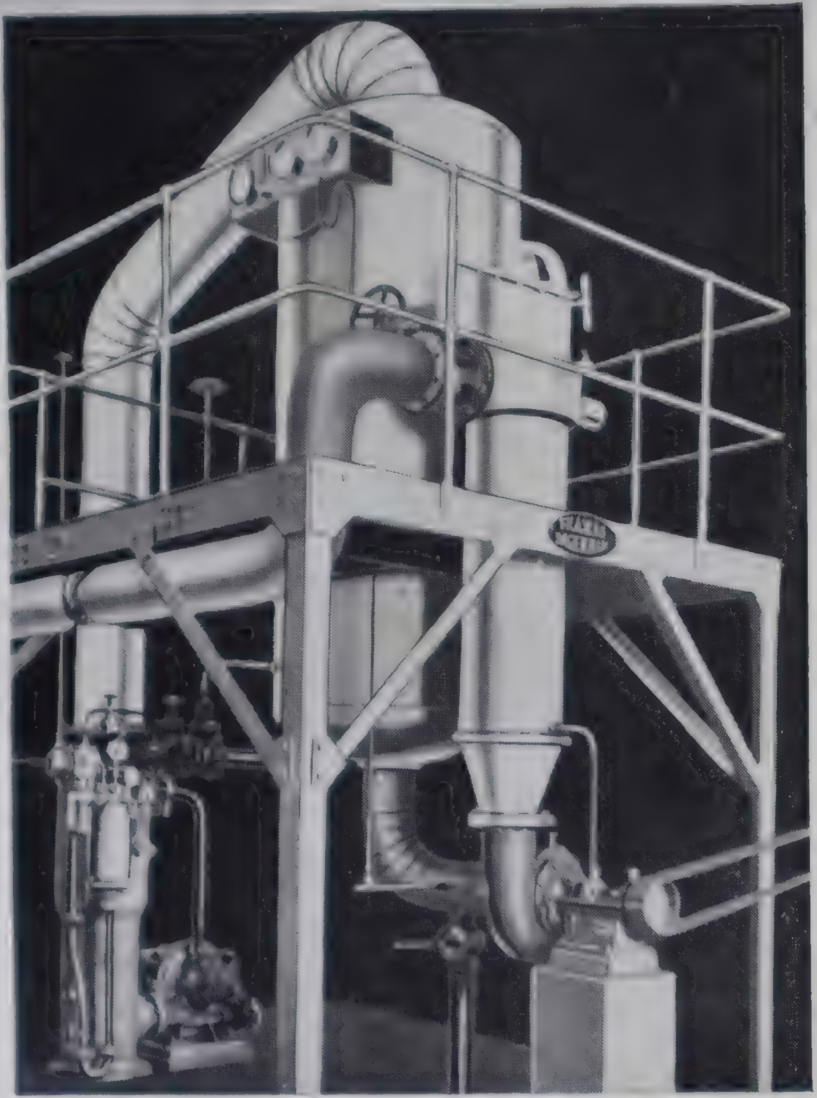


Fig. LXIII. Fraser Stainless Steel Forced Circulation Evaporator

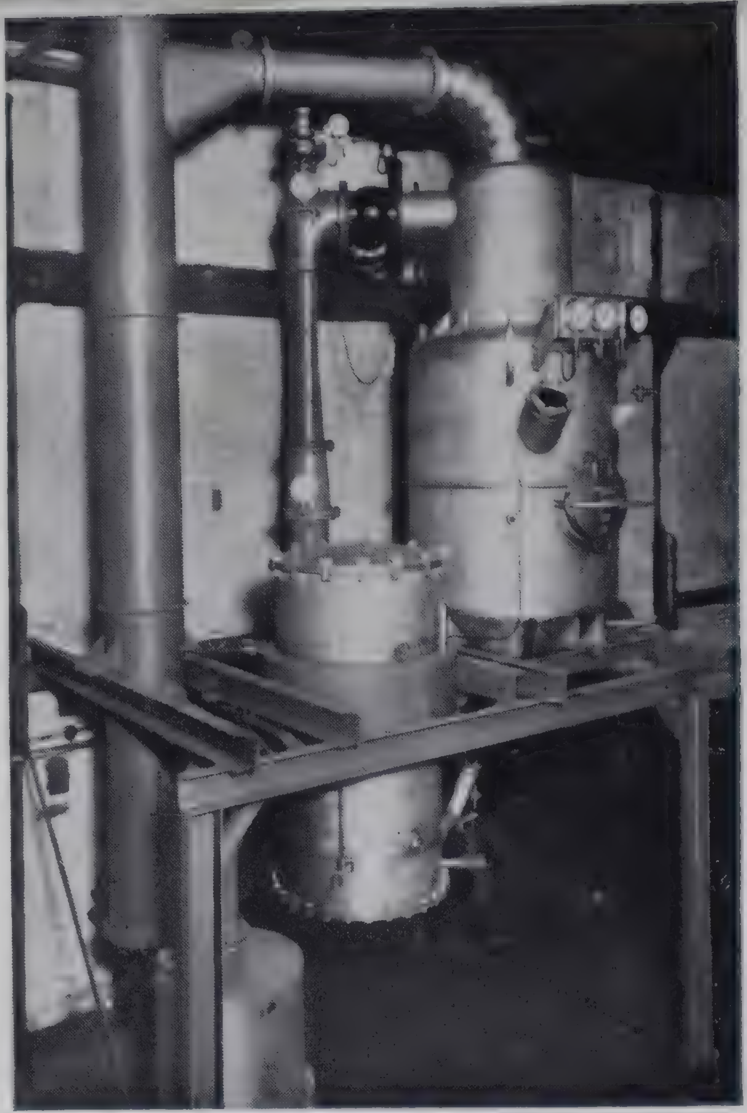


Fig. LXIV. Fraser Stainless Steel Natural Circulation External Calandria Evaporator

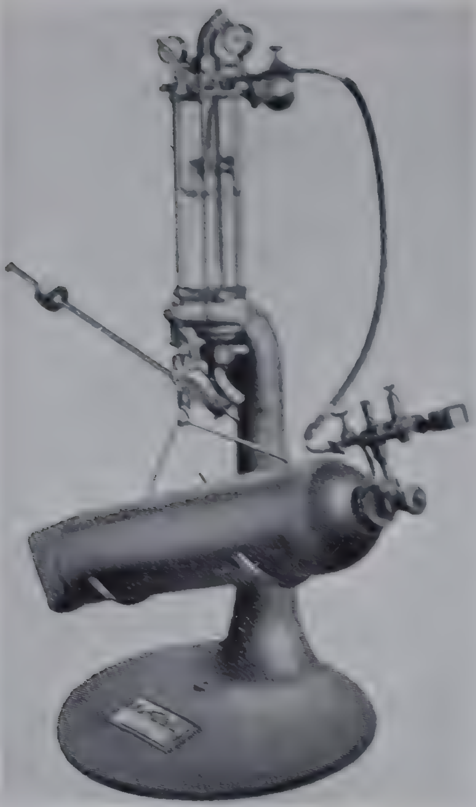


Fig. LXV. French CO_2 Saturating M
(Kendall Model)

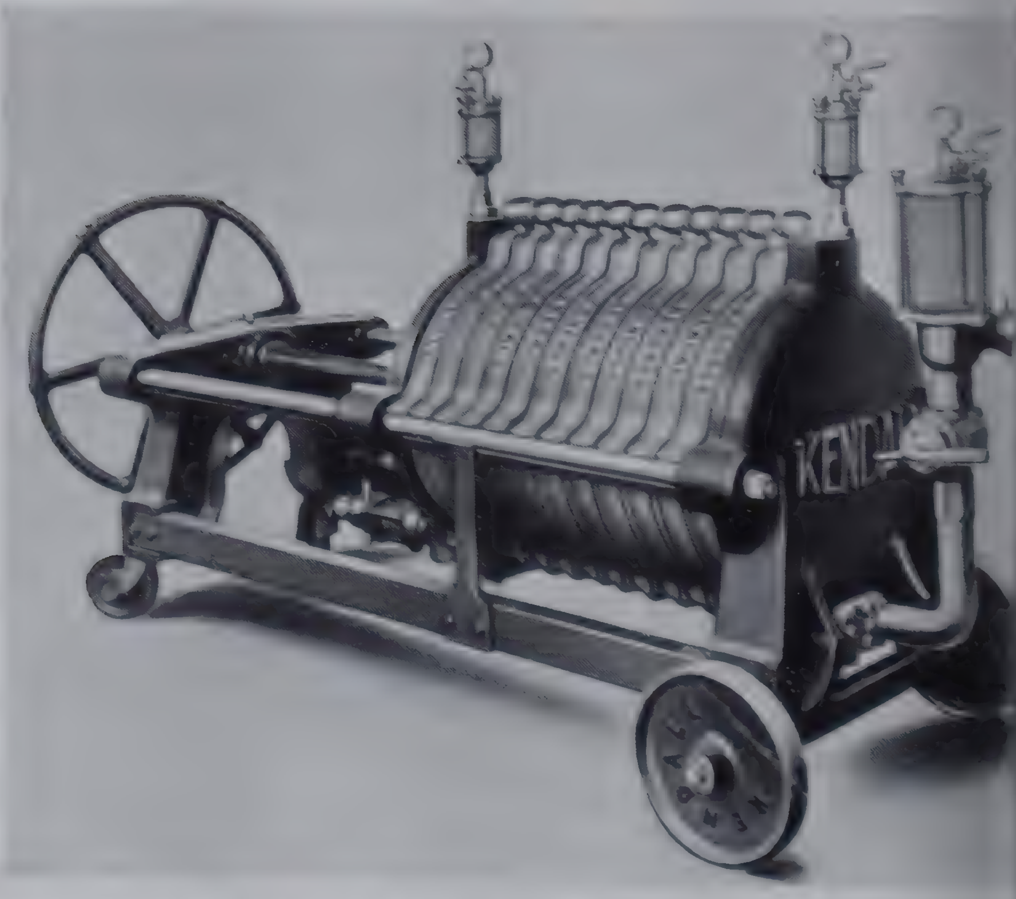

KEND
KENDALL

Fig. LXVII. French Cider Filter (Kendall Type)

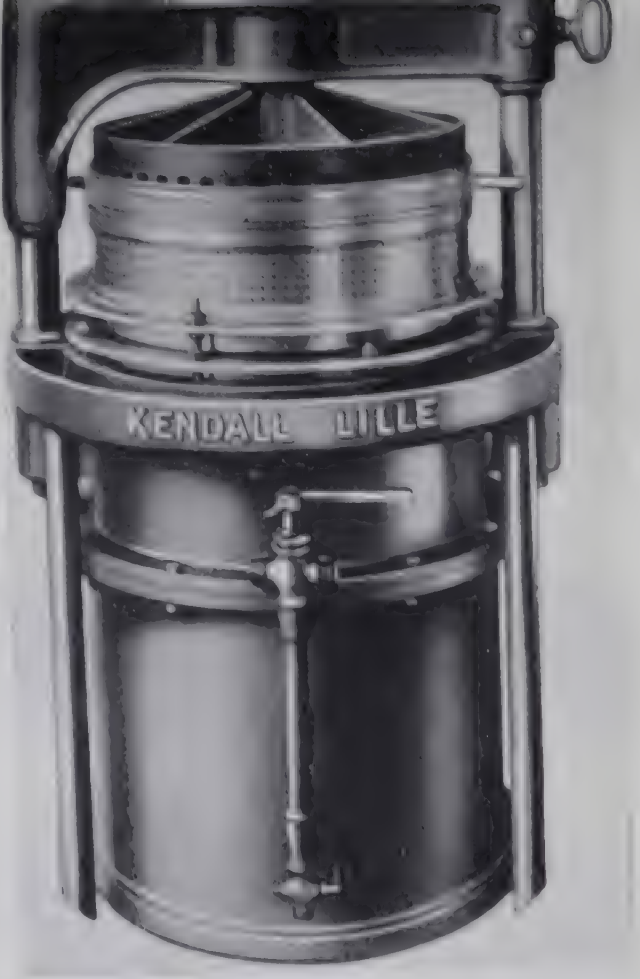

KENDALL LILLE

FIG. LXVIII. French Press for Filter Pulp
Kendall Type)

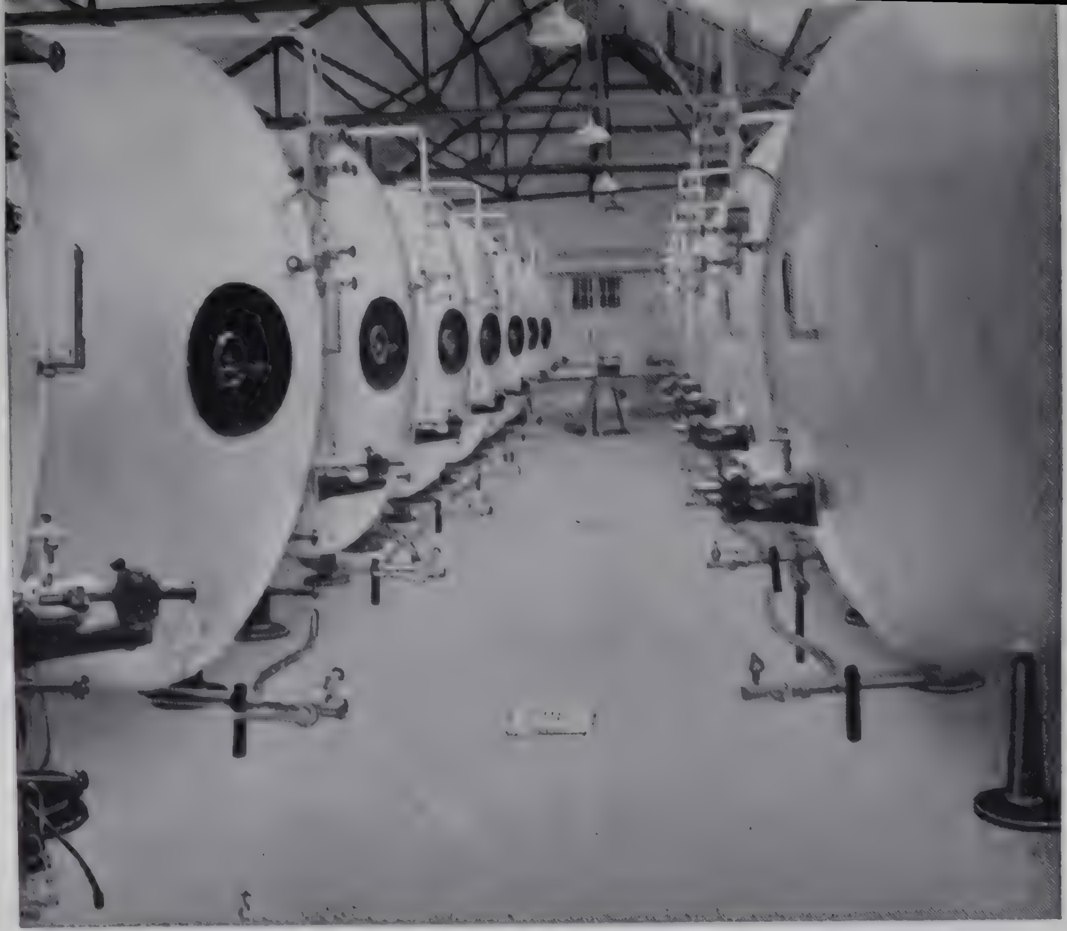
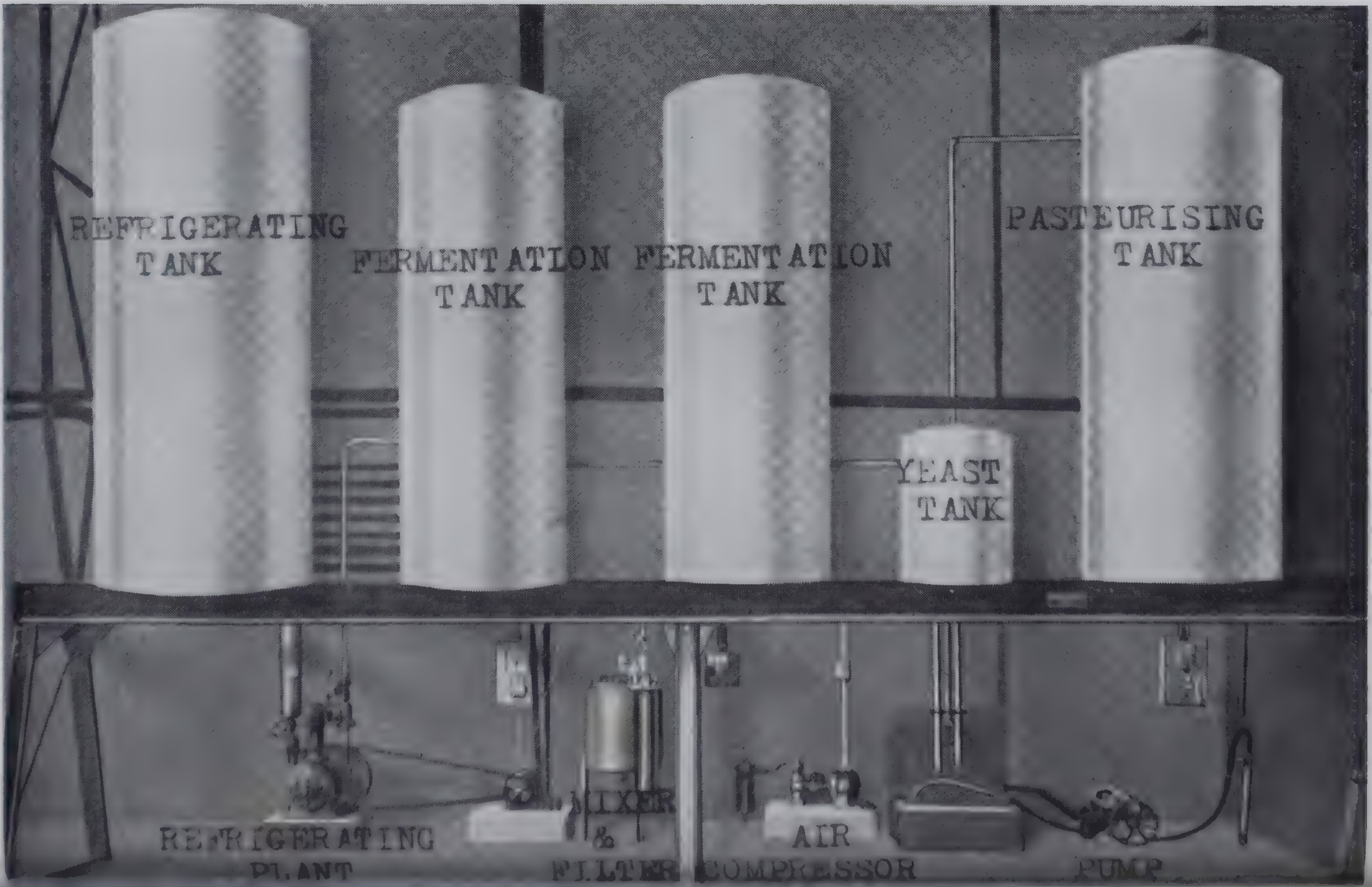


FIG. LXIX. Battery of Redox Tanks for Sparkling Cider Production


REFRIGERATING TANK
FERMENTATION TANK
FERMENTATION TANK
YEAST TANK
PASTEURISING TANK
REFRIGERATING PLANT
MIXER & FILTER
AIR COMPRESSOR
PUMP

percentage of total sugar is reduced by 0·1 and multiplied
0·06, this giving the percentage of potential alcohol by
ume.

.g. If a cider contains 1·6% sugar, the calculation becomes:
1·60 − ·1 = 1·5 × 0·06 = 0·09% potential alcohol by volume.

Where the alcohol is required on a weight basis, the necessary
bles can be consulted.

(ii) *Method of the French Syndicate of Cider and Cider Fruits.*—
1922, this Syndicate advised its makers to utilise the follow-
g method for total alcohol.

(*a*) The actual alcohol should be determined on a neutralised cider by the distillation method.

(*b*) The potential alcohol is estimated from an accurate determination of the specific gravity of the cider. The last two figures of the gravity are divided by the following numbers:

8·5 for gravities from 1·015 and above.
9·0 for gravities from 1·014 to 1·010.
10·0 for gravities from 1·009 to 1·003.

Liquors with gravities below 1·003 are not regarded as being capable of producing any further alcohol. The sum of these two alcohol contents provides the figure for the total alcohol content of the cider. This method is as accurate as the fuller method when applied to cider, but considerable errors are involved with the analysis of perry.

otal Alcohol

By definition, the total alcohol content of a cider is the sum
the actual and potential alcohol contents of the liquor.

ry Extract at 100°C.

20 ml. of cider are pipetted into a round flat-bottomed plati-
um dish, 5·5 cm. diameter and 2·5 cm. deep. The dish is heated
a water bath, accurately levelled, with openings 5 cm. in
iameter which are completely closed either by the dishes or
ecial covers. The water level in the bath should be 5-6 cm.
elow the cover. The dish is heated over the boiling water for
hours, after which it is removed from the bath, carefully dried
nd allowed to cool in a dessicator before the final weighing.

Reducing Sugars

100 ml. cider are measured into a flask graduated at 100 a 110 ml. capacity. The cider is saturated with powdered sodiu bicarbonate followed by the addition of a small amount neutral lead acetate (10% solution), taking care not to add excess of the latter reagent. The flask is filled to 110 ml., a the contents are well mixed and filtered. A little sodium bic bonate is added and the liquor again filtered. The sugar determined in the filtrate by the use of Fehling's solution (5 being equivalent to 25 mg. of glucose).

Reducing sugars can also be determined by the polarimet

Sucrose

100 ml. of cider are measured into a 100-110 ml. graduat flask, 2·5 ml. of 10% hydrochloric acid are added and the m ture immersed in a boiling water bath for 5 minutes. Af cooling, the liquor is titrated against Fehling's solution and t difference in sugar content between the titration before a after inversion, multiplied by 0·95, gives the sucrose conte

Sugar-free Extract

This is obtained by subtracting from the figure for total tract the sum of the reducing sugars and sucrose less 0·1%. more than 10% of residual sugar is present in the cider or per this must be removed by fermentation. A small quantity yeast is added to the sweet cider which is then incubated 25-28°C. for several days, after which the necessary determi tions are repeated.

Vacuum Extract

5 ml. of cider are pipetted into a glass dish, 7 cm. diame and 2·5 cm. deep. The dish is placed in a vacuum dessica provided with a dish of strong sulphuric acid, the area of being at least twice that of the test vessel. The dessicato evacuated and left for four days. The dish is then provided w a weighed glass cover, and after weighing a suitable calculat enables the vacuum extract to be determined.

Total Acidity

(*a*) 5 ml. of cider are heated to 80°C. on a water bath i glass dish with a flat bottom. After cooling, 5 drops of an alco ution of phenolphthalein are added, and the cider titrated h N/20 soda from a burette; the soda is run into the cider y slowly, and, finally, drop by drop until the colour change effected. If x is the number of mls. of N/20 soda used to utralise the cider, then $x \times 0{\cdot}049\%$ gives the total acidity ex-essed as sulphuric acid, or $x \times 0{\cdot}067\%$ as malic acid.

(*b*) *Method used at Caen.*—100 ml. of water are placed in a sk and brought to 80°-90°C.; 2-3 drops of phenolphthalein e added and the solution titrated with N/10 soda until the se colour is permanent even after agitation. (The soda needed r this need not be measured.) 5 ml. of cider are then added to e flask and soda is again run into the mixture until a persistent se colour is assured. This method is quick and accurate.

(*c*) *Dujardin Acid Tester.*—This little instrument is extremely luable for quick estimations in the factory.

ixed Acidity

The vacuum extract is used for this determination. 5 ml. of ater are added and the mixture gently warmed. The solution titrated with standard soda.

olatile Acidity

This figure can be obtained by subtracting the fixed from the tal acidity. The Duclaux and Mathieu methods give very ccurate results; the former is very widely practised in French boratories.

ree and Fixed Volatile Acidity

In ciders that contain abnormally high ash contents rich in lkaline carbonates, there is always a suspicion that such products have been partially saturated with some alkaline material. f this is so, the preceding method will not give a sufficiently igh figure for the total volatile acids. In these cases, tartaric cid is added to liberate the fixed volatile acids.

5 ml. of cider are placed in a glass flask 7 cm. in diameter and ·5 cm. deep and 5 ml. of N/20 tartaric acid solution in 20% lcohol are added. This solution is then evaporated in vacuo. he residue is treated with 5 ml. of N/20 soda to neutralise xactly the added tartaric acid. After complete solution has een obtained, the final titration is carried out as before. The

acidity thus determined, subtracted from the total acidity, provides a figure for the total volatile acidity. This procedure when applied to normal ciders gives results for total volatile acidity only slightly greater than for direct volatile acidity. The difference, however, becomes much greater in ciders that have been partially saturated with alkaline materials.

Total Tartaric Acid

The official method or the alcohol-ether method of Berthelot are not satisfactory; Warcollier has found the method of Kling (*Annales des Falsifications*, June 1910) to be the most satisfactory. It is based on the precipitation of tartaric acid as the calcium racemate.

Ash

50 ml. of cider are evaporated in a platinum dish of 7 cm. diameter. The dry residue is subjected to a moderate heat for half an hour until charring is completed; the process is then continued in a muffle at red heat until all carbon has been burnt away. The ash is then cooled in a dessicator and weighed very quickly. Should it prove to be difficult to remove the carbon at the first attempt, the black charred mass should be moistened with a few mls. of water and the two treatments repeated.

Alkalinity of Ash

The ash is taken up in water, the solution filtered, and an aliquot of the solution titrated with N/10 sulphuric acid, using methyl orange as an indicator. The results are usually evaluated as potassium carbonate. It is also possible to calculate the alkalinity in terms of potassium bimalate.

Citric Acid.

The method of Deniges enables a qualitative test to be applied for the presence of citric acid in cider. 10 ml. of cider are agitated with 1 g. lead dioxide followed by addition of 2 ml. of mercuric sulphate.[1] After further mixing the solution is filtered. 5 or 6 ml. of the filtrate are boiled in a test tube and one drop of 1% potassium permanganate is added. When decolouration is completed, 11 further drops of permanganate are added. Normal ciders show a very slight clouding at this stage. Citric acid present to the extent of 0·02% causes a very definite cloud; at 0·04%, citric acid gives rise to a flocculent precipitate.

[1] Mercuric oxide 5 g., Sulphuric acid (conc.) 20 ml., Water 100 ml.

This method can be used for quantitative results by using solutions containing known amounts of citric acid for comparison tests.

Tannin (non-official)

The method of Manceau is based on the absorption of tannin by hide or gut, and has the advantage of avoiding gravimetric procedure whilst accounting for the whole of the tannin in the cider. The following reagents are needed:

(i) Violin gut that has not been oiled is blanched with water containing oxygen and digested for 1 hour with a dilute solution of sulphuric acid containing a little potassium permanganate. The gut is washed and finally dried between two porous plates.

(ii) Potassium permanganate solution (0·02-0·03%).

(iii) A solution of indigo is prepared by dissolving 1 g. of this material in 50 ml. pure sulphuric acid; several days later, the solution is made up to 1 litre with distilled water.

(iv) A solution of tannin is made by dissolving 1 g. pure dry gallotannin in 1 litre of distilled water.

Method.—Ciders rich in tannin should be diluted with water until their presumed content of tannin is about 0·01%. 100 ml. of cider are added to each of two flasks and in one of these is placed about 1 g. of dried cat gut. Both flasks are set aside at a temperature of about 10°C. for 4-6 hours. During this time, the tannin in one flask will be absorbed by the gut and thus removed from the cider. The titration procedure is somewhat complicated. 1,500 ml. of cold water and 10 ml. indigo solution are placed into each of two 2-litre glass flasks. To the first is added 25 ml. of untreated cider, whilst to the other is added 25 ml. of the cider treated with gut. Potassium permanganate is added to each flask by means of a burette until the green colour completely disappears when viewed by reflected light (the flasks should be placed on a white surface so that the colour change can be more easily observed). Constant agitation should be secured during the titration. The green colour should not reappear after one or two minutes interval. At this stage, the precise tints of the liquids in the two flasks should be identical.

The difference in value of permanganate solution taken for the two flasks corresponds to the amount of tannin in 25 ml.

of cider. The permanganate must be standardised against a pure tannin solution. 1,500 ml. of water and 10 ml. of indigo are placed in a 2 litre flask; similar amounts of water and indigo are also added to another flask but in this case 5 ml. of the prepared solution of pure tannin are also added. Both flasks are titrated with permanganate solution, the difference in the titrations corresponding to 5 mg. of pure gallotannin.

If V represents the value of permanganate solution used in the first titration of the cider sample and Y the value used in the second, then V – Y represents the amount of permanganate corresponding to the tannin in 25 ml. of cider. Further, if T equals the titration figure for the permanganate solution, then the tannin content, expressed as percentage of gallotannin, is give by the formula

$$T(V - Y) \times 4$$

Manceau points out that this method differs from that of A. Girard, which gives a gravimetric evaluation of the actual tannin content, whereas the method described above provides a figure calculated in terms of one known pure form of tannin.

Pectic Materials (non-official)

Pectins can be precipitated by alcohol. 100 ml. of cider are evaporated to 10-15 ml. and treated with 60-80 ml. of 95% alcohol. The precipitate is washed on a tared filter paper with 80% alcohol, then dried at 20°C. and later at 100°C. The dry precipitate is then weighed. The accuracy of this method leaves much to be desired, for the precipitate contains some non-pectic material. Some improvement can be obtained by ashing the precipitate and subtracting the weight of the ash from the total weight.

Sulphurous Acid (total sulphur dioxide)

(*a*) 25 ml. of N. caustic potash and 50 ml. of cider are placed in an Erlenmeyer flask; the vessel is closed and agitated and left at room temperature for 15 minutes. The aim of this procedure is to decompose the compounds formed between sulphur dioxide and aldehydic substances in the cider, and to ensure that the whole of the sulphur dioxide is ultimately brought into the form of potassium sulphite. 10 ml. of dilute sulphuric acid (1 volume strong acid + 2 volumes of water) are added to the flask, plus a few drops of starch solution as an indicator and the mixture is titrated with N/50 iodine solution. The titration figure in millilitres multiplied by 0·00128 gives the total sulphurous acid content as a percentage (wt./vol.).

(*b*) If the above method indicates a sulphur dioxide content greater than 0·01% (100 p.p.m.) the following method can be used. A flask of 400 ml. capacity is fitted with a cork with two holes. Through one of these is led a tube which reaches to the bottom of the flask and which carries a supply of carbon dioxide. The other hole is fitted with a glass tube attached to a Peligot tube, each bowl of which should have a capacity of 100 ml. The apparatus is first swept through with carbon dioxide to remove air. The Peligot tube is provided with 30-50 ml. of iodine solution (5 g. iodine and 7·5 g. potassium iodide per litre). The cork of the 400 ml. flask is removed, and whilst the carbon dioxide is still passing into the apparatus, 100 ml. of cider and 5 ml. of concentrated phosphoric acid are run into the flask; the cork is replaced, and after a short interval the contents of the flask are heated until half the cider has distilled over into the Peligot tube, which should be immersed in cold water. The current of carbon dioxide must be maintained throughout the process. There should be some free iodine remaining in the Peligot tube at the end of the distillation. The contents of the tube are washed into a flask, and the sulphuric acid can be determined by precipitation. The weight of barium sulphate obtained from the solution should be multiplied by 2·7439 to give the amount of sulphur dioxide present in one litre of cider.

Sulphurous Acid (free)

The free sulphur dioxide can be approximately estimated in a cider by employing the first method for total sulphur dioxide given above, but omitting the caustic potash reagent and carrying out the titration immediately and not after a 15 minute interval.

The sulphur dioxide content of apple juices and ciders can also be determined by using special instruments designed by the firm of Dujardin for employment with the Mathieu method.

Detection of Sugar Added for Sweetening

Warcollier has published a method (*Bulletin Assoc. Française* *pomologique*, 2nd volume, 1908), the outline of which is described here.

In naturally sweet ciders retaining between 1-6% of sugar, it can be shown that the ratio $\frac{\text{glucose}}{\text{laevulose}}$ is smaller than 0·4; i.e. there is always two and a half times as much laevulose as glucose. Again, in some ciders, the glucose can completely disappear, in which case the ratio becomes zero.

Now, consider the case of a cider sweetened with sucrose and containing a minimum of 1% of total sugar.

(*a*) The cider may rotate the plane of polarised light to the right, from which it may be concluded that added sugar is present, since all naturally sweet ciders rotate the plane of polarised light in the opposite direction. The nature of the added sugar can be elucidated as will be shown below.

(*b*) The cider, on the other hand, may rotate the plane of polarised light to the left. An analysis will indicate that the ratio $\frac{\text{glucose}}{\text{laevulose}}$ is always between 0·5-1·0, which suggests that sugar has been added as the ratio for naturally sweet ciders is always below 0·4.

If the analysis is performed immediately after the cider has been sweetened and therefore before the sucrose has been inverted by the added tartaric acid, or if the sucrose has not been inverted by the sucrase of the yeast, the analyst can decide on the origin of the sucrose. Its presence in considerable amounts in a cider containing only traces of reducing sugars points to the inclusion of sucrose in the sweetening process.

Sweetening with glucose.—(The addition of glucose to cider is forbidden in France.) If the cider is dextro-rotatory, some sweetening agent is indicated. Should the analysis show the ratio $\frac{\text{glucose}}{\text{laevulose}}$ to be greater than or equal to 1, the addition of glucose is confirmed.

Alternatively, if the cider is laevorotatory the ratio $\frac{\text{glucose}}{\text{laevulose}}$ may still be greater than or equal to 1.

In general, a study of the value of the above ratio will enable the analyst to determine whether a cider containing a minimum of 1% of total sugar has been sweetened and also what sugar was used in such a process. This analytical procedure is especially appropriate for ciders that have been sweetened only after they have fermented almost to dryness. It is ineffective for detecting the addition of sugar to fresh juices or to ciders during the main fermentation. Its use, however, in the former case, gives exact information on the nature of the sugar addition.

Translator's Addenda

The analyses given by Warcollier are all still employed in the French cider industry. Alternative methods, such as Lane & Eynon's sugar titration, Monier-William's method for sulphur dioxide, and special techniques for other constituents of cider can be found in various textbooks on food analysis, amongst which may be cited:

(i) *Official and Tentative Methods of Analysis of the Association of Official Agricultural Chemists*. Washington, D.C., U.S.A., 1945.

(ii) *Aids to the Analysis of Food and Drugs*. John R. Nicholls (Baillière, Tindall and Cox, London) 1945.

An interesting method for titration of acidity in cider has recently been described by L. F. Burroughs in the *Annual Report* of the Long Ashton Agricultural and Horticultural Research Station for 1946 (p. 122). The method involves the use of a mixture of bromo-thymol blue and phenol red as an indicator. The titration is carried out in the presence of carbon dioxide-free air in a 4 oz. medicine bottle. There is no interference by the natural pigments of the cider.

Extract

In view of the fact that extract and sugar-free extract data are being considered for use in the analytical control of the composition of cider, it is important to refer to alternative methods for extract determination. The Office International du Vin in Rome published in 1934 a method for the determination of extract by taking the specific gravity of the residual liquor after the alcohol had been distilled off. The gravity of the extract was divided by 3·86 to give the percentage of extract 'solids'. Should a factor other than 3·86 be used, this fact should be made clear on the analysis.

An American official method for wines involves a specific gravity determination, and is given in the Official and Tentative Methods of Analysis of the A.O.A.C. (5th Ed.) p. 165, No. 9.

The Swiss official method also departs from the drying procedure of Warcollier and utilises a specific gravity determination. Special tables by Ackermann are used for the conversion of gravity figures into extract precentages. The methods are given on p. 30 of *Manuel Suisse des denrees alimentaires* (4th Ed., published by Zimmermann & Co., Berne, 1939).

CHAPTER XXII

COMPOSITION OF CIDER

CIDER that has been carefully made and stored under clean conditions is a refreshing beverage with nutritive, tonic and health-giving properties. Hauchecorne considers it to be the most thirst quenching and hygienic of all fermented drinks for the summer months.

Dr. Denis-Dumont has shown by investigations in the Normandy and Brittany areas that cider possesses remarkable properties in preventing the formation of stone in the bladder. He has established the practically complete immunity of cider drinkers from this disorder, gout, etc. The presence of malic acid is responsible both for the powerful diuretic power of cider in activating the action of the kidneys and minimising the accumulation of uric acid.

In an earlier chapter, reference has been made to the research of Dr. Bodin on the bactericidal power of cider.

Modern knowledge of vitamins has not brought to light any evidence that cider can be regarded as an important source of any known accessory food factors.

Analytical Data

A number of tables are given here to indicate the extremely wide variations in the analysis of cider. The chemical analyses are taken from the publications of Warcollier, Lechartier and the Municipal Laboratory of Paris. Fuller analytical data can be found in the researches of Andouard, Brioux, Cochetelle, Jay, Kayser, Lechartier, Perrier, Rocques, Warcollier, etc., whilst the *Bulletins de l'Association française pomologique* contain numerous papers dealing with this aspect of the subject.

TABLE XXIII.—ANALYSES OF COMMERCIAL CIDERS FROM CALVADOS (Warcollier)

Origin	*Specific Gravity*	*Actual Alcohol* % wt.	*Total Alcohol* % wt.	*Sugar-free Extract* % w/v	*Total Sugar* % w/v	*Ash* % w/v	*Total Acidity (malic acid)* % w/v	*Tannin* % w/v
Bissières -	1·032	1·99	4·96	2·6	6·2	0·266	0·205	0·120
Bissières -	1·016	2·80	4·40	2·0	3·4	0·273	0·233	0·120
Bissières -	1·022	1·83	4·00	2·8	4·5	0·279	0·301	0·205
Bissières -	1·034	1·27	4·64	2·5	7·0	0·276	0·205	0·115
Mittois -	1·009	4·32	5·29	1·95	2·05	0·225	0·301	0·145
Saint-Michel-de-Livet -	1·025	2·96	5·29	2·9	4·8	0·385	0·219	0·185
Plainville -	1·007	4·80	5·45	2·1	1·4	0·280	0·520	0·175
Plainville -	1·002	4·64	4·80	1·75	0·4	0·284	0·370	0·150
Coteaux-du-Bosq	1·037	0·79	4·80	2·02	8·25	0·319	0·191	0·210
Hermival -	1·035	0·72	4·08	2·16	7·00	0·325	0·288	0·185
Danestal -	1·017	1·99	3·60	1·8	3·3	0·260	0·356	0·200
Gonneville-sur-Dives -	1·020	2·88	4·88	1·63	4·15	0·231	0·274	0·130
Littry - -	1·007	4·16	4·96	1·6	1·7	0·243	0·342	0·185
Longues -	1·035	2·39	5·94	2·0	7·3	0·250	0·205	0·320
Longues -	1·020	2·64	4·88	1·55	4·65	0·220	0·374	0·330
Bayeux -	1·016	2·72	4·56	1·8	3·8	0·175	0·260	0·200
Nonant -	1·012	3·52	4·80	2·3	2·6	0·299	0·356	0·215
Nonant -	1·011	4·48	5·69	2·3	2·5	0·300	0·219	0·295
Littry - -	1·009	3·84	4·72	1·8	1·9	0·285	0·219	0·155
Bayeux - -	1·019	3·04	5·13	2·4	4·3	0·324	0·191	0·290
Maizet - -	1·012	2·39	3·52	2·01	2·3	0·248	0·329	0·210
Escoville -	1·006	5·13	5·77	1·74	1·4	0·294	0·465	0·340
Troarn -	1·011	3·68	4·88	1·98	2·5	0·293	0·452	0·205
Tournebu -	1·023	2·88	5·04	2·10	4·5	0·260	0·410	0·190
La Pommeraye	1·012	4·80	5·85	1·85	2·2	0·251	0·315	0·230
Clécy - -	1·005	4·64	5·22	1·80	1·1	0·295	0·356	0·235
Thury-Harcourt	1·007	3·84	4·80	1·95	2·0	0·272	0·342	0·160
Vire - -	1·003	2·96	3·44	1·65	1·05	0·291	0·374	0·150
Ouistréham	1·032	2·96	6·18	1·9	6·6	0·220	0·383	0·155
St.-Philbert-des-Champs -	1·030	2·15	4·88	3·05	5·6	0·283	0·301	0·190
Carpiquet -	1·007	4·00	4·80	1·7	1·6	0·240	0·315	0·210
Isigny - -	1·024	2·31	4·88	1·8	5·4	0·296	0·397	0·220

TABLE XXIV.—ANALYSES OF PURE JUICE CIDERS (Lechartier)

Origin	*Actual Alcohol* % wt.	*Total Alcohol* % wt.	*Total Sugars* % w/v	*Sugar-free Extract* % w/v	*Ash* % w/v
Calvados - -	1·27-5·37	4·72-7·56	0·28-6·50	1·74-3·08	0·227-0·322
Seine-Inférieure -	1·75-5·22	4·80-7·15	0·17-7·83	1·89-3·45	0·184-0·491
Eure - - -	2·88-3·68	4·24-6·10	0·64-6·80	2·02-2·12	0·328
Orne - - -	2·96-5·37	4·88-5·77	0·17-4·36	1·51-2·42	0·222-0·186
Manche - -	5·37-6·10	5·85-6·75	0·12-1·75	1·64-1·99	0·191
Sarthe - -	4·64-6·02	6·10-7·15	2·05-2·67	2·25-2·46	0·292-0·327
Mayenne - -	1·91-3·60	4·56-6·02	1·69-5·34	1·67-2·55	0·184-0·205
Côtes-du-Nord -	2·72-3·92	5·13-5·29	2·53-4·84	1·47-2·13	0·209-0·272

TABLE XXV.—ANALYSES OF PURE JUICE CIDERS FROM CALVADOS (Warcollier)

Origin	*Specific Gravity*	*Actual Alcohol* % wt.	*Total Alcohol* % wt.	*Dry Extract at 100°C.* % w/v	*Total Sugars* % w/v	*Sugar-free Dry Extract* % w/v	*Ash* % w/v	*Total Acidity (malic acid)* % w/v	*Volatile Acidity (acetic acid)* % w/v
Calvados	1·013	3·52	4·96	5·32	3·05	2·27	0·305	0·465	0·17
,,	1·011	3·12	4·24	4·37	2·45	1·92	0·330	0·561	0·12
,,	1·014	3·36	4·64	5·04	2·65	2·39	0·295	0·561	0·16
,,	1·012	3·04	4·08	4·40	2·20	2·20	0·335	0·575	0·17
,,	1·007	4·00	4·56	3·28	1·25	2·03	0·310	0·575	0·12
,,	1·019	2·72	4·48	5·92	3·85	2·27	0·325	0·458	0·12
,,	1·017	2·55	4·40	5·73	3·85	1·88	0·275	0·438	0·13
,,	1·021	2·55	4·40	6·16	4·10	2·06	0·275	0·438	0·09
,,	1·018	2·63	4·40	5·77	3·70	2·07	0·305	0·397	0·11
,,	1·008	4·80	5·53	4·04	1·45	2·59	0·320	0·397	0·11
Maximum	—	—	7·23	—	—	3·10	0·390	—	—
Minimum	—	—	4·00	—	—	1·65	0·170	—	—

TABLE XXVI.—ANALYSES OF VARIOUS PURE JUICE CIDERS
(Various Analysts)

Origin	*Specific Gravity*	*Actual Alcohol* % wt.	*Total Alcohol* % wt.	*Dry Extract at* 100°C. % w/v	*Total Sugar* % w/v	*Sugar-free Extract* % w/v	*Ash* % w/v	*Fixed Acidity (malic)* % w/v	*Volatile Acidity (acetic)* % w/v	*Analyst*
Orne	1·030	3·80	7·07	8·620	6·860	1·760	0·287	0·097	0·291	Lechartier
Manche	0·999	5·45	5·61	1·988	0·344	1·644	0·194	0·150	0·372	,,
Sarthe	1·008	6·02	6·99	4·513	2·048	2·465	0·338	—	0·244	,,
Mayenne	1·027	1·91	4·40	7·894	5·345	2·549	0·205	—	0·125	,,
Ille-et-Vilaine	1·000	4·64	4·80	2·104	0·453	1·651	0·175	0·404	0·090	,,
Ille-et-Vilaine	1·016	3·28	4·96	5·149	3·551	1·598	0·170	0·167	0·106	,,
Seine-Inférieure	—	4·80	5·77	4·90	2·00	2·900	0·350	0·342	0·134	Municipal Laboratory, Paris
Seine-Inférieure	1·000	4·56	4·56	3·320	Traces	3·320	0·504	0·563	—	
Calvados	1·004	3·60	4·00	3·160	0·908	2·252	0·308	0·375	—	,,
Calvados	1·010	3·12	4·00	4·308	1·920	2·388	0·248	0·341	—	,,
Manche	0·999	4·00	4·00	1·84	0·025	1·82	0·269	0·288	0·11	Warcollier
Manche	1·006	4·80	5·45	3·75	1·45	2·30	0·280	0·328	0·16	,,
Manche	1·005	5·69	6·42	4·25	1·45	2·80	0·317	0·374	0·03	,,
Manche	1·000	5·21	5·29	2·00	0·20	1·80	0·274	0·205	0·13	,,
Manche	1·034	2·63	6·02	9·20	7·15	2·05	0·310	0·246	0·13	,,
Manche	0·999	4·80	4·84	2·10	0·10	2·00	0·279	0·137	0·09	,,
Manche	1·024	3·36	5·69	6·80	4·00	1·90	0·320	0·342	0·12	,,

CHAPTER XXIII

FOOD REGULATIONS CONCERNING CIDER AND PERRY[1]

Most extensive regulations governing the composition and sale of cider and perry are prepared by the French Ministry of Agriculture. The original regulations were drawn up in 1905 and these have since been modified by decrees dated 20th August 1930 and 24th September 1933, the last mentioned being still in force in 1948.

The full regulations are set out below.

French Cider and Perry Regulations

Section I

(i) No beverage may be stocked, transported, offered for sale or sold under the name of 'cider' if it is not prepared exclusively by the fermentation of the juice from fresh apples, or a mixture of fresh apples and pears, the juice extraction being accomplished either with or without the use of potable water.

(ii) No beverage may be stocked, transported, offered for sale or sold under the name of 'perry' if it is not prepared exclusively by the fermentation of the juice from fresh pears, the juice extraction being accomplished either with or without the use of potable water.

Section II

(i) The designation 'pure juice cider' or 'pure juice perry' is reserved for cider or perry prepared without the addition of water.

(ii) The designation 'cider' or 'perry' is reserved for cider or perry containing a minimum of

3·2% alcohol (wt./vol.) (actual or potential).
1·3% (wt./vol.) sugar-free dry extract at 100°C.
0·13% (wt./vol.) of ash (neglecting any salt added as a specific treatment).

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[1] Up-to-date regulations have been inserted here by the translator.

(iii) All beverages prepared by the fermentation of the juice of fresh apples or pears and showing lower quantities of alcohol, dry extract and ash than the above limits, but in which the figures are greater than

2·0% alcohol (wt./vol.) (actual or potential),
0·7% sugar-free dry extract at 100°C.,
0·08% ash (qualified as above),

should be designated as 'fresh apple beverage' (*boisson de pommes fraiches*) or 'fresh pear beverage' (*boisson de poires fraiches*); 'apple beverage (*boisson de pommes*) or 'pear beverage' (*boisson de poires*).

(iv) The beverages defined above must not be sold for consumption if they have acetic taints or if the volatile acidity is greater than 0·30% acetic acid, unless the product is acceptable to the purchaser.

(v) The use of any designation including the term 'cider' for the description of any beverages other than those specifically defined in the first two paragraphs of this regulation is entirely forbidden in any form whatever

(*a*) on the bottle and wrappers.
(*b*) on the labels, capsules, corks, seals, or any other closing devices.
(*c*) in trade papers, invoices, catalogues, prospectuses, price lists, signs, posters, advertisements, announcements or any other form of publicity.

(vi) Beverages for which dried apples have been used as a basis may not be stocked or sold unless they are designated as 'dried apple beverage' or 'dried pear beverage' (*boisson de pommes seches, boisson de poires seches*) or under some general description not containing the terms 'cider', 'perry', 'apple', or 'pear'. These beverages may not possess an alcohol content of less than 2·0% or more than 2·4% (wt./vol.).

Section III

All processes will be deemed to be fraudulent if they have for their aim the modification of the composition of the cider or perry defined in the preceding Section, or the deception of the purchaser concerning the essential quality or origin of the product.

Section IV

The processes enumerated below and having as their sole m the regular, standard production of cider and perry are ermitted:

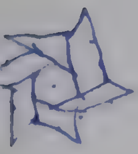
) Concerning ciders and perries:

- (*a*) The blending of various ciders together.
- (*b*) The blending of various perries together.
- (*c*) The blending of ciders with perries.
- (*d*) The blending of ciders or perries with 'fresh apple beverages' or 'fresh pear beverages'.
- (*e*) The blending of ciders or perries with fresh apple or pear juice.
- (*f*) The employment, for sweetening of cider or perry or for the preparation of sparkling ciders and perries, of
  - (i) sucrose (the sugar added for this purpose should not be included in the calculation of alcohol content).
  - (ii) concentrated apple or pear juice.
  - (iii) fresh apple or pear juice preserved with sulphur dioxide, provided that the blend does not retain an amount of sulphur dioxide greater than that fixed in a later paragraph.
- (*g*) The concentration of ciders and perries by freezing or any other procedures.
- (*h*) Pasteurisation, filtration, racking or use of pure gaseous oxygen or pure carbon dioxide.
- (*i*) Fining processes by agents such as pure albumin, casein, gelatin or isinglass, or any other product which may be allowed by the Ministries of Public Health and Agriculture on the advice of the Council of Public Hygiene and the Academy of Medicine.
- (*j*) The addition of a maximum of 0·1% of salt.
- (*k*) The addition of tannin.
- (*l*) The addition of pure sulphur dioxide produced by the combustion of sulphur or from pure crystalline alkaline bisulphites, provided always that the cider or perry does not retain more than 0·02% (200 p.p.m.) sulphur dioxide, free or fixed, with a tolerance of 10% in excess of this amount, and that the amounts of alkaline bisulphite used are limited to 0·01% (100 p.p.m.).

- (*m*) The addition of tartaric and citric acids at the ma mum dose of 0·05 % (wt./vol.).
- (*n*) Artificial colouring by means of cochineal, caram chicory or any other colouring agent declared to permissible by the above mentioned authorities.

(2) Concerning juices:

- (*a*) The addition of sucrose.
- (*b*) The addition of concentrated apple or pear juice.
- (*c*) The addition of tannin, pure crystalline ammoniu phosphate or calcium phosphate (commercial purity
- (*d*) The use of selected yeasts.
- (*e*) The addition of a maximum of 0·1 % salt.
- (*f*) Treatment with a maximum of 0·01 % pure crystalli alkaline bisulphites.
- (*g*) Treatment with pure sulphur dioxide without a limitation as to amount.
- (*h*) Removal of sulphur dioxide from preserved juices physical means so that the products offered for sa satisfy the above regulations with respect to this pr servative.
- (*i*) The addition of tartaric or citric acids to the pulp juice, provided always that the cider or perry pr duced therefrom does not contain more than the ma mum dose allowed by these Regulations.
- (*j*) The concentration of juices.



Section V

No cider or perry can be stocked, transported, offered for sa or sold solely under the designation 'sparkling cider' or 'spar ling perry' unless its sparkling condition is entirely the result a prolongation of the fermentation process.

When the aeration of a cider or a perry is produced, even part, by the incorporation of carbon dioxide, the term 'spar ling' may be used in its description, but this must be modifi by the term 'fantaisie' or some qualification differentiating t product from that referred to in the previous paragraph. T two terms must be printed in characters of equal size.

Section VI

In retail stores, the vessels, wrappers, bins or casks used for e storing of the cider or perry should carry an inscription indi- ting the exact designation under which the product is being ld. This inscription is not essential on containers or bottles in hich the product is taken away by the purchaser or used by e seller to dispense the product when the beverage is to be nsumed on the premises.

Section VII

The employment of any indication, suggestion or sign capable creating in the mind of the purchaser any confusion on the ature or origin of the cider or perry offered for sale is forbidden.

Application of the French Regulations

The above regulations lay down precise definitions for cider nd perry products. It is of interest to consider how the purity f a cider or perry can be established.

No general formula for the composition of pure juice ciders an be given. The only satisfactory method involves the com- arison of the sample with a genuine pure juice cider made with ruit from the same district and in the same season. French pure uice ciders generally have a minimum alcohol content of 4·16% y weight. This figure may fall to 4·0% or rise to 4·8%, whilst ccasionally contents as high as 7·23% have been noted.

The data for sugar-free dry extracts varies according to the egion, variety and quality of the fruit, the age of the cider and ts degree of fermentation. Initial figures of 2-3% are reduced o 1·5-1·6% at later periods of the life of the beverage.

The fixed acidity varies considerably as a result of many factors. Tannin contents range from 0·02-0·35%, pectins and gums from 0·05-0·6%, and ash from 0·17-0·41%. These compounds, therefore, cannot be used as criteria of purity.

Lechartier has tabulated some generalisations concerning the composition of the ash.

(*a*) 80-92% of the ash is composed of constituents that are soluble in water.

(*b*) The soluble fraction of the ash is almost entirely contributed by the salts of potassium, which are present to a minimum extent of 50% of the ash (more often the proportion is between

56-60%). Warcollier has noted two cases where the potassiu salts contributed 62% and 65% of the total ash. Sodium sa are present only in minor quantities and calcium oxide is nev found in the ash.

(*c*) The soluble salts are associated with phosphoric and ca bonic acids. In general, the carbonic acid is present to an exte of 22-29% of the weight of the ash. In cider, the potassium sa exist largely as salts of organic acids. The amounts of chlorid and sulphates are very small.

(*d*) Phosphoric acid to the extent of 4·3-10% is found bo in the soluble and insoluble fractions of the ash. The total weig of the two bases, lime and magnesia, is less than 10% of the tot ash (4·5-9·1%), the two bases being present in approximate equal amounts.

The data given below refer to the ash constituents in vario French ciders:

	Ille-et-Vilaine %	*Manche* %	*Orne* %	*Seine-Inférieure* %
Silica - -	0·0017	0·0010	0·0007	0·0020
Phosphoric acid	0·0229	0·0205	0·0126	0·225
Sulphuric acid -	0·0145	0·0065	0·0063	—
Chlorine - -	0·0023	0·0020	0·0014	—
Aluminium and iron oxides - -	0·0017	0·0015	0·0013	—
Lime - - -	0·0050	0·0042	0·0074	0·0100
Magnesia - -	0·0037	0·0080	0·0038	0·0150
Potassium - -	0·0970	0·1113	0·1465	0·1730
Sodium - -	0·0020	0·0021	0·0014	0·0015
Total ash - -	0·1805	0·1980	0·2242	0·2787

The analysis of a pure juice cider from the Calvados distri can be given as:

Alcohol -	4·0% (wt./vol.)
Dry extract	1·7%
Ash - -	0·20%

The regulations would thus be satisfied if a product contai ing 70% pure juice Calvados cider and 30% water were so as 'cider'. The same dilution is possible in most of the oth areas of France where cider is produced.

Cider-makers should, however, not profit by their ability exercise this dilution, except in years of very short crop apples.

Sweetening of Cider.—Whilst sweetening of juices and ciders is lowed by law, it is important to regulate the addition so that e major contribution to alcohol formation is provided by tural rather than added sugar. The sugar should never be lded in such a way as to alter completely the nature of the der under treatment.

Sophistication of Cider.—In the examination of ciders suspected being sophisticated, it is useful to refer to the following list normal constituents of ciders and perries:

Water; ethyl alcohol, propyl alcohol, butyl alcohol, amyl cohol; glucose, laevulose, sucrose; glycerin; aldehydes; gums, ectins; fixed organic acids (free and combined); malic, suc- inic and tannic acids; volatile organic acids (carbonic, acetic, ropionic, butyric, valeric); phosphoric, sulphuric and hydro- hloric acids combined with the following bases – potassium, alcium, magnesium, aluminium, iron, manganese, sodium, lica; ethers (ethyl, propionic and butyric); sorbite.

Ciders affected by disorders may also contain mannite, lactic cid and considerable amounts of acetic acid.

CHAPTER XXIV

THE MANUFACTURE OF PERRY

PERRY is a beverage produced exclusively by the fermentatio of the juice from fresh pears, extracted from the fruit either wit or without the addition of water. It is a clean beverage wit excellent general qualities, but possessing neither the aroma n softness of flavour of cider. Perry retains its own specific tast which, whilst it is dissimilar from that of cider or wine, blend extremely well with either, and the beverage is, in fact, ofte used in combination with the apple drink.

Certain high-class perries from the Passais (Orne) district France can be mistaken for white wines. If, on the other hand they are bottled at a suitable time, they develop their own ga and become similar to champagne.

Generally speaking, high quality perries suitable for consumption by themselves are very rare in France. They must b produced from specially selected fruit which is given particularly careful treatment and consequently perry is more ofte converted into distilled liquors. The growing of perry pears i much less extensive in the Western areas of France than that cider apples.

Normandy produces the best perry pears, those from the districts of Passais, Bocage and Mayenne being famous for thei quality. The perries made locally are used for consumptio from casks or bottles, or for more general sale as imitations certain types of still white wines or sparkling products.

The best varieties of pears for perry making contain littl acidity and tannin (less than 0·4% and 0·3% respectively) Amongst these varieties are *Invoie*, *Grosse grise*, *Hecto*, *Souris* *Chennevière*, *Fignot*, *Friche*, *Paronné*, *Tabac*, *Août*, *Bouc*, *Fumée*, *Saint-Denis*, *Antricotin*, *Courcou*, *Falaise*, *Rouge Vigny*, *Jument*, *Caris* *blanche*, *Huchert*, *Gris-de-Loup*, *Roulain*, *Carisi rouge*, *de Branch* *Chemin*, *Pochon blanche*, *Renard*, *Ruet*.

Other varieties with higher acid and tannin contents are use for eaux-de-vie production. The following varieties are culti ted in the Orne and Calvados regions of France: *Charbonnet*, *oignet*, *Gris crasseux*, *Crassane sauvage*, *Hyverne*, *Pillo*, *Poire sucrée*, *ête-de-Chat*, *Vert-Lamoricière*, *Branche de Fournay*, *Blot ou Gaubert*, *loche*, *Chandelle*, *Chien rouge*, *Gros-Coignet*, *Fosset*, *Gros-Gontier*, *onguet*, *Longpré*, *Marais*, *Oignon*, *Plant de Blanc*, *Petit-Roux*, *enaude*, *Rouget*, *Saule*, *Trochet*, *Vache*, *Fer*, *Billon*, *Blanchard*, *Cra-as*, *Petite-Grise*, *Gros Blanc*, *Messirat*, *Mousset*, *Platé*, *Quenette*, *onchonnière*, *Petite-Tête*, *Gros-Vert*.

The above segregation of varieties into two groups is quite rbitrary as the characters of the individual sorts vary from ear to year and according to soil and other cultural conditions. gain, it is possible by careful blending to produce a perry hich is suitable for either purpose; i.e. distillation or direct onsumption.

The full list of varieties of perry pears has been given in Warcollier's treatise on Cider Apples. This includes a list of dual urpose pears for propagation in Normandy. Amongst these are *Plant de Blanc* and *Grosse-Grise*, both of which were recommended by the French Pomological Association.

Sugar Content

Truelle has provided a table which shows the relationship between the specific gravity of the juice and the sugar content (Table XXVII). Many varieties of perry pears provide juices with gravities as high as those from cider apples, and thus it is obvious that the finished perries will possess alcohol contents as

TABLE XXVII.—RELATIONSHIP BETWEEN SUGAR CONTENT OF PEAR JUICES AND SPECIFIC GRAVITY

Specific Gravity	*Sugar per cent by volume*	*Specific Gravity*	*Sugar per cent by volume*	*Specific Gravity*	*Sugar per cent by volume*
1·043	9·5	1·053	11·0	1·063	13·1
1·044	9·6	1·054	11·2	1·064	13·2
1·045	9·8	1·055	11·3	1·065	13·3
1·046	9·9	1·056	11·5	1·066	13·4
1·047	10·1	1·057	11·6	1·067	13·6
1·048	10·2	1·058	11·8	1·068	13·7
1·049	10·4	1·059	11·9	1·069	13·8
1·050	10·5	1·060	12·1	1·070	14·0
1·051	10·7	1·061	12·2	1·071	14·1
1·052	10·8	1·062	12·4	1·072	14·3

high as those of pure juice ciders. In general, however, pear juices have a lower gravity than cider apple juices, although they yield more eau-de-vie than is the case with cider, on account of the much higher yields of juice obtained from the pears than from the other fruit.

Chemical Composition of Pears

The variation in analysis is very extensive, but some idea of the nature of the chemical composition of pears is given in Table XXVIII which was prepared by Truelle.

TABLE XXVIII.—CHEMICAL COMPOSITION OF PEARS

	Specific Gravity	*Reducing Sugars*	*Sucrose*	*Total Sugars*	*Tannin*	*Acidity as Malic*	*Pectins*
I.—Analyses based on juice (% by volume)							
Minimum -	1·045	8·369	1·203	10·556	0·035	0·194	Traces
Maximum -	1·072	13·000	2·086	14·984	0·797	1·387	1·28
Mean - -	1·062	10·074	1·735	11·896	0·230	0·552	0·39
II.—Analyses based on pulp (% by weight)							
Minimum -		7·924	0·147	8·080	0·044	0·044	Traces
Maximum -		12·076	2·078	13·400	0·484	0·828	1·20
Mean - -		9·882	1·081	11·017	0·158	0·357	0·48

Perries of the Domfront Area

Special mention must be made of the perries produced in the Domfront area, of which a study has been made by Chevalier and reported in the French cider journal, *Semaine du cidre.* These notes are based on his report.

Perry pear orchards constitute one of the chief features of the Domfront region, and more particularly in the cantons of Domfront, Passais and Juvigny-sous-Andaines (Orne). Despite the extensions in cider orcharding in this area, perry pears still represent the largest acreage devoted to fruit and this is true also of the cantons of Barenton, Le Teilleul (Manche), Ambrières and Lassay (Mayenne).

The production of perry in the three Departments, Orne, Manche and Mayenne, was estimated in 1928 as being 22 million gallons in a good season. The three cantons of Domfront, Passais and Juvigny can themselves produce one quarter of this quantity. Certain farms of 25 acres can produce 4,500 gallons of perry in a season, and certain old orchards can produce 445-675 gallons of perry per acre. Some old trees reach 60 ft. in height, with a girth of trunk greater than 9 ft., and one tree in Passais provided enough fruit to produce 550 gallons of juice. In this area, perry is the normal beverage consumed on the farms, but for best effect it should be consumed during the year following that in which it was made. Large quantities are also sold for distilling, but the most useful product is a bottled perry, reminiscent of certain white wines of Anjou. In some years, perry is distributed in the Angers-Saumur area and it is certainly used in the preparation of some wines exported by this district.

Varieties.—All the perry pear trees of the Domfront region are grafted, even those of the greatest age. Amongst the many local varieties, twelve are of high repute and are listed here in order of importance:

Gros-Blot, *Rouge-Vigny*, *Longuet*, *Plant-de-Blanc*, *Antricot*, *Fossey*, *Raguenet*, *Courcou*, *Bézier*, *Brionne*, *Gontier*, *Sept-Forges* and *Pommeret*.

Most of the varieties are very bitter, but *Saint-Laurent*, *Perdereau*, *Bézier*, *Poire de vigne* are suitable for eating. These four varieties do not travel well. *Poire de Cloche* is used for confectionery. The area of Basse-Normandy does not grow any dual-purpose pears such as *Poire de Curé*, which is so prolific a variety in Montargis.

Whilst single varieties of pears in the Domfront area are not kept separate for milling, pears are never mixed with apples, even for distillation. This probably accounts for the high reputation of the perry in the Passais area. Perry pears produce 140-170 gallons of juice per ton. To obtain a high quality perry for bottling, a juice should be prepared by blending to the following approximate analysis: specific gravity 1·055, sugar 11·2% by weight, tannin less than 0·3%, acidity less than 0·55%.

Treatment of Perry Pears—Maturation

The maturing process in pears is different from that of cider apples. The cells of the pear tissue are affected by the asphyxiation due to the production of pectin which fills the intracellular spaces. The cells of the pear must necessarily be provided with air if they are to live, and thus the cells die when the air supply is cut off. The fruit shrivels and mellows; the cells die rapidly, and most pears cannot possibly be kept for any length of time after harvesting.

During the maturing and softening of the pears, the greater part of the pectin is coagulated in the fruit itself, which explains why juices from some varieties which have been milled in a ripe condition do not contain any pectin or pectic materials. Some pears soften one or two days after being taken from the trees and such fruit must be milled immediately. Others, such as *Billon*, *Hyverne verte*, *Gris-de-Loup*, *Grosse-Grise*, are of harder consistency, travel better and take much longer to soften.

There is no precise rule regarding the storage of pears. The perry-maker must take every precaution to ensure that the pears are milled before they become quite soft. For very astringent pears, experience has shown that it is important to mill the fruit when the core of the pear alone has begun to soften.

Perry Pears Suitable for Transport

The following varieties can be transported from the orchard to the factory without difficulty:

Ascension, *Attrape-goule*, *Avoine*, *Blanbeau*, *Blanc*, *Blanche grise tardive*, *Canteloup*, *Clos-Reuil*, *Cocon*, *Cogneu*, *Cornil*, *Crapaud*, *Crassane sauvage*, *Enfer* (*d'*), *Fer* (*de*), *Friche*, *Halleg-gerbirne*, *Haut-Pin* or *Haut-Clocher*, *Héri*, *Huchet*, *blanche et grise*, *Gris crasseux*, *Grisette*, *Gros-Dudan*, *Hyverne rousse*, *Jacob*, *Jacquot*, *Lima* or *de Rouen*, *Monsieur* (*de*), *Morin* or *Gris Morin*, *Moque-Friant* or *Trompe-Friant*, *Nérousse*, *Noël* (*de*), *Noisette* (*de*), *Normande blanche*, *Parc* (*de*), *Plant de Blanc*, *Platé*, *Quenette*, *Quessey*, *Queue-de-Chat*, *Roulette*, *Roux*, *Ruet-Safran*, *Saint-Michel*, *Sauvagets*.

These varieties, if they have been carefully harvested and stored in heaps no greater than 2 ft. deep, may be successfully stored without decomposition for a period of three weeks. Certain other varieties, such as *Fer*, *Gris-de-Loup*, *Grosse-Grise*, *Hyverne*, may be kept for two months when suitable storage is provided.

Manufacture

Pears that have been harvested under poor conditions should always be washed before being milled. The normal form of apple washer is not suitable for pears, for the fruits—being heavier than water—sink to the bottom of the tank with the impurities.

Pears are generally more difficult to mill than apples, and strong, carefully constructed mills are necessary. The juice exerts a corrosive action on all metal surfaces with which it comes in contact and all metal plant should be maintained in a scrupulously clean condition. A moderate degree of maceration is acceptable, especially when the perry is intended for consumption as such. Warcollier has shown that during a maceration extending over 12 hours, the pectase is dissolved into the juice and is thus instrumental in aiding the clarification of the juice. Very bitter fruit pulp should always be macerated; this process softens the hard tissues and increases the ultimate yield of juice.

The juice from pear pulp is usually obtained with ease in some form of press, the yield being normally higher than that from apples. For this reason, it is not always necessary to use water when the pears are at optimum maturity and when the fruit has been milled at the stage immediately preceding the softening of the tissues.

In good seasons, it is unnecessary to have recourse to re-soakings, but in poor years it is permissible to employ such a treatment in the same way as for apples.

Keeving should be regularly introduced into the process. Pears vary with regard to their pectase contents. Some are relatively rich in this enzyme, and their juices clarify rapidly and effectively, whilst other varieties are not so well provided and the pectic substances coagulate much more slowly.

Certain varieties of pears exhibit to a considerable degree the power of self-clarification. Such varieties are chiefly found in Switzerland where they are regularly employed as defecating agents for apple juice. These pears are known locally as *Scheidbirnen*.

Truelle regards the whole clarification process as of chemical origin; he suggests that clarification of the juice only commences when the media contain a minimum of 0·3% of tannin, albumins, pectins and malic acid; maximum clearing occurs when the total of the same four constituents is increased to 0·8%.

Warcollier, on the other hand, stresses the importance of the presence of pectase and other coagulating materials, such as salts of calcium, aluminium, etc. It can be said of pears that there is a certain maturity associated with each variety at which it should be milled if maximum clarification is to be achieved. This fact must be appreciated by the perry-maker so that he can study his fruit accordingly. Perfect clarification has been obtained by Warcollier with varieties such as *Bry de la Coudre*, *Huchet*, *Plant-Blanc*, *Bec-d'oie*, *Longuet*, *Fer*, *Rouget*, *Gaubert* (all from the Passais area).

Experiments have also shown that some apple juices that clarify badly can be effectively treated by one of the following methods:

(*a*) Addition of 5-10% of perry pear juice in the correct condition for clarification.

(*b*) Mixing the apple juice with the pear pulp in the correct condition for clarification.

(*c*) Macerating the apple pulp with the pear pulp in the correct condition for later clarification.

Keeving of the pear juice should be effected at low tempe tures. The head will be less coloured and less voluminous t for apples, but it becomes very compact and shows no sign the intervention of a white head. The juice should be withdra from between the top and bottom deposit and fermentat immediately induced. For the production of bottled perry w a long period of stability, fermentation should be carried at low temperatures, but perries for immediate consumption for distillation can be fermented at 20°C., with the addition 1½ oz. ammonium phosphate per 100 gallons. Pure perry champagne yeasts may be used with advantage.

If the keeving process fails to produce a clear juice, the p duct will commence and continue to ferment without previ clarification. This leads to the formation of white or milky p ries, which have only poor keeping qualities. This conditio entirely due to the milling of the fruit either in an under or o ripe condition. When this milky condition persists, it can treated in one of several ways. In the first case, the juice sho be mixed with a separate batch of pear pulp which it is inten to macerate; alternatively, the juice should be mixed with other juice that has shown perfect clarification, whilst as a resort the milky perry should be mixed with a fermented c or perry.

The clarification and stabilisation of perry is effected in ex ly the same way as for cider (i.e. racking, filtration, finin Perry is liable to contract the same disorders as cider, and p ventive and curative treatments are identical with those alre given for the other beverage. Müller-Thurgau has shown presence in perry of a mannite fermentation, in which man and lactic and acetic acids are formed.

TRANSLATOR'S ADDENDA

Perry has largely ceased to be an important beverage b in France and England. Small quantities are still produced areas of intensive growing of perry pears but generally the f is mixed with apples and milled with them. There is onl slight literature dealing with perry and the only reference t will be made here is to a paper by Grove on the preventio milkiness in perry. This troublesome condition is persisten e seasons with perries from certain varieties. The perry from ck pears has been known to form a solid gel on storage, thus iously involving a pectin problem of some complexity. Using ries made from Holmer, Blakeney Red, Oldfield, Huffcap Butt pears, Grove found that the milkiness which formed in ples could be entirely prevented by the use of potassium tabisulphite at the rate of 3¼ oz. per 100 gallons (*Ann. Rept.* *g Ashton Res. Sta.*, 1930, p. 208).

CHAPTER XXV

UTILISATION OF FRESH APPLE POMACE

The apple residues remaining in the cloths after the expres of the juice in the hydraulic presses possess a definite value should on no account be discarded.

In 1928, France was producing annually about 2½ mil tons of fruit for juice production. If it is assumed that one q ter to one third of the weight of fresh fruit used in proces remains as pomace, and if allowance is made for fruit expo to other countries, it is probable that the industry could with 700,000 tons of pomace. The value of this material ca estimated at more than six million francs (£50,000) if it used as a manure or compost, or at seventy million fr (£560,000) calculated on its value as a feeding-stuff (1928 pr

Apple pomace may be used in two forms:

(*a*) As fresh pomace or converted into a silage for the fee of livestock; as a silage for use in distilleries; as fresh pomac the production of pectin for confectionery purposes; or manuring the ground.

(*b*) As dried pomace for the feeding of livestock, either a or with the incorporation of molasses; and for the prepara of pectins, etc., for the confectionery trade.

Fresh Pomace

The composition of the product varies according to the cedure adopted for the expression of the juice. Those pom that are prepared by single pressing of the milled fruit are na ally richer than those which have been subjected to two or t re-soaking processes. Table XXIX shows the results of var workers on the variation in composition of pomace mad different ways.

Warcollier has pointed out that pressed pomace samples hydraulic presses contain at least 72% of moisture and 2 of sugar, whilst the pomaces produced by the continuous pr for ultimate distillation retain 80% water and 1-2·5% of su

Table XXIX.—Composition of Apple Pomace
(% by weight)

ition of Pomace	Houzeau Unexhausted pomace	Houzeau Exhausted pomace	Lechartier Unexhausted pomace	Wolff Exhausted pomace	Warcollier Pomace from diffusion process	Warcollier Pressed after pomace exhaustion
- - - - -	80·18	80·11	75·75	74·3	90·10	78·15
compounds	0·73	1·02	1·37	1·4	0·60	1·5
- - -	0·69	0·75	1·26	1·3	0·48	0·82
free extracts*	14·84	11·32	8·28	11·2	3·8	13·50
llulose - -	2·88	6·00	12·08	10·5	3·6	5·10
naterials -	0·68	0·80	0·65	1·3	0·50	0·93

* Sugars are included in the nitrogen-free extracts

eeding-Stuffs for Stock.—The value of pomace as a source of ients for livestock has been known since 1887 (Houzeau). tables of values determined by Wolff show that a fresh nace contains about 0·8% of digestible protein, 0·7% of y substances, 12·3% of carbohydrates. The relative nutritive ue (ratio of protein to non-protein constituents) is thus ap- ximately 1/18.

Kellner has produced more accurate data indicating that h pomace contains the following digestible constituents: % protein, 0·3% fat, 9·2% nitrogen-free extractives and % cellulose. This corresponds to a nutritive value, calculated tarch, of 9·5 per 100 units of pomace. The nutritive ratio is 5, which indicates that the product is deficient in nitrogen.

Fresh pomaces that have not been produced by re-soaking atments may contain up to 6-7% sugar and in this case they ve a nutritive value which approaches that of partially ex- usted sugar beet residues.

Freshly pressed pomaces have a nutritive value similar to t of sugar beet residues sold for fodder and the fresh residues m sugar factories, and can be blended with other food con- ntrates such as dried malt grains, barley, beans and oilcake, the feeding of animals. The blended foodstuff may then ssess a nutritional ratio of 1/5 to 1/12.

Animals can be accustomed to the consumption of apple mace provided that they are given small doses at the com- encement.

100 lb. of fresh pomace are roughly equivalent to 30 lb. of od hay. Pomace is especially suitable for ruminants, but cer-

tain precautions in its use are necessary. The residues should be spread about immediately they come from the press, as a delay will give rise to a sharp penetrating smell which will repel the animals. The pomace must be given in small amounts and should never be left in heaps on the grass.

The pomaces should generally be utilised as mixtures with straw, cereal husks, rape, hay or straw chaff, and should be fortified with concentrates such as molasses.

The straw and husk materials should be mixed with the pomace 8-12 hours before feeding it to the animals so that the food may soften and become easily digestible.

The maximum amounts of fresh pomace that should be fed to each animal per day are as follows: 20-30 lb. for working oxen; 20 lb. for milking cows and horses; 10 lb. for fattening cows; 2 lb. for sheep; 4-6 lb. for pigs (this ration is better assimilated if the pomace is first cooked or soaked with boiling water). When used in these proportions no deterioration in the health of the livestock need be anticipated on account of the onset of diarrhoea, or by inducing miscarriage in cows in calf. No foreign taste will be imparted to the milk.

Cornevin claims that diarrhoea can be avoided by limiting the daily amount of pomace to 20-30 lb. and by combining this ration with a dry constituent. The taint of milk and miscarriage of cows was due, in his opinion, to the feeding of pomace that had been badly preserved and had deteriorated as a result of the action of mould and abnormal fermentation processes.

Silage from Fresh Pomace.—Fresh pomace has very limited keeping qualities. Only a few days' contact with air are necessary for the onset of fermentation and decay which render it unfit for consumption. The stabilisation of the pomace may be effected by converting it into a silage, and Warcollier has published a report on this important matter (Warcollier, 'Utilisation of fresh pomace in the feeding of cattle'; *Bulletin Association Française pomologique*, 1928).

Well disintegrated, fresh pomace stacked in a closed space and completely freed from its contained air, undergoes a normal alcoholic fermentation. The pomace material having an acid reaction, there is no fear of the development of putrifying bacteria which only operate in a neutral or alkaline medium. The surface of the pomace, however, must be protected against

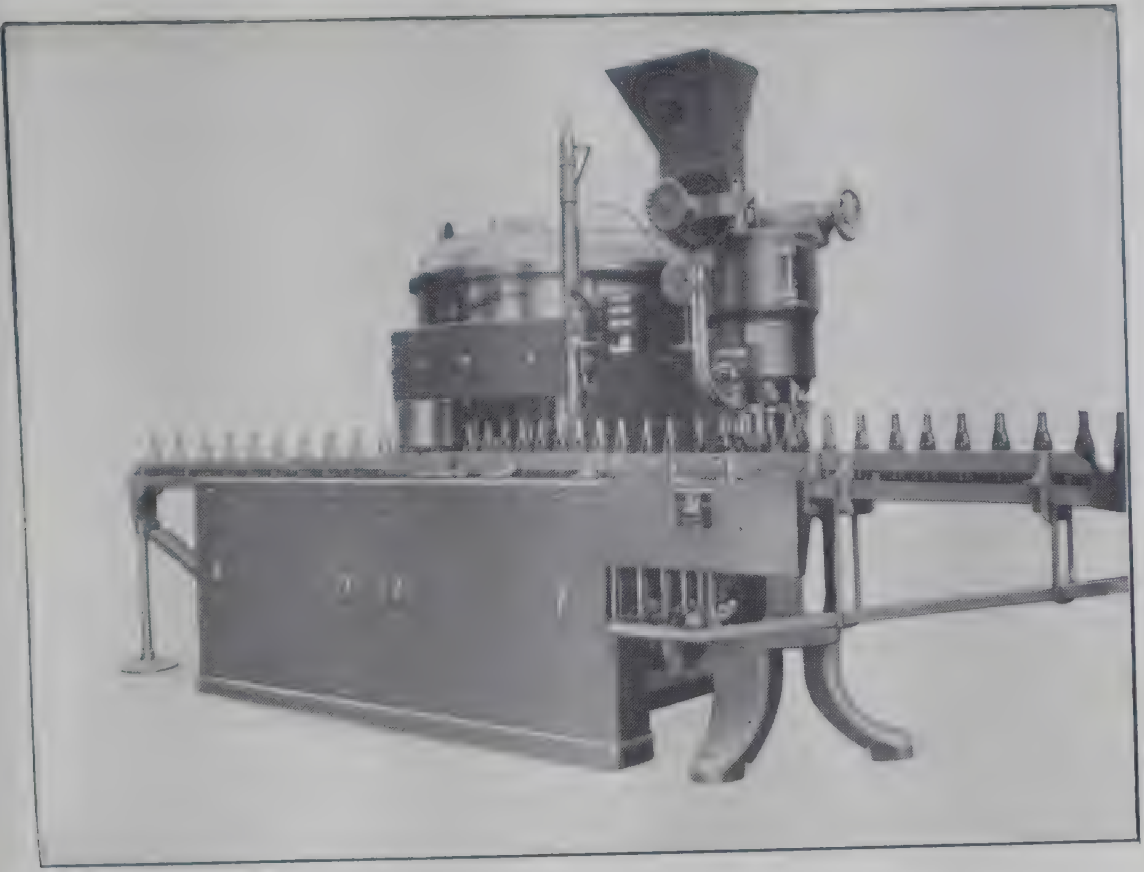


FIG. LXXII. Bratby & Hinchcliffe Automatic Cider Filling and Crowning Plant

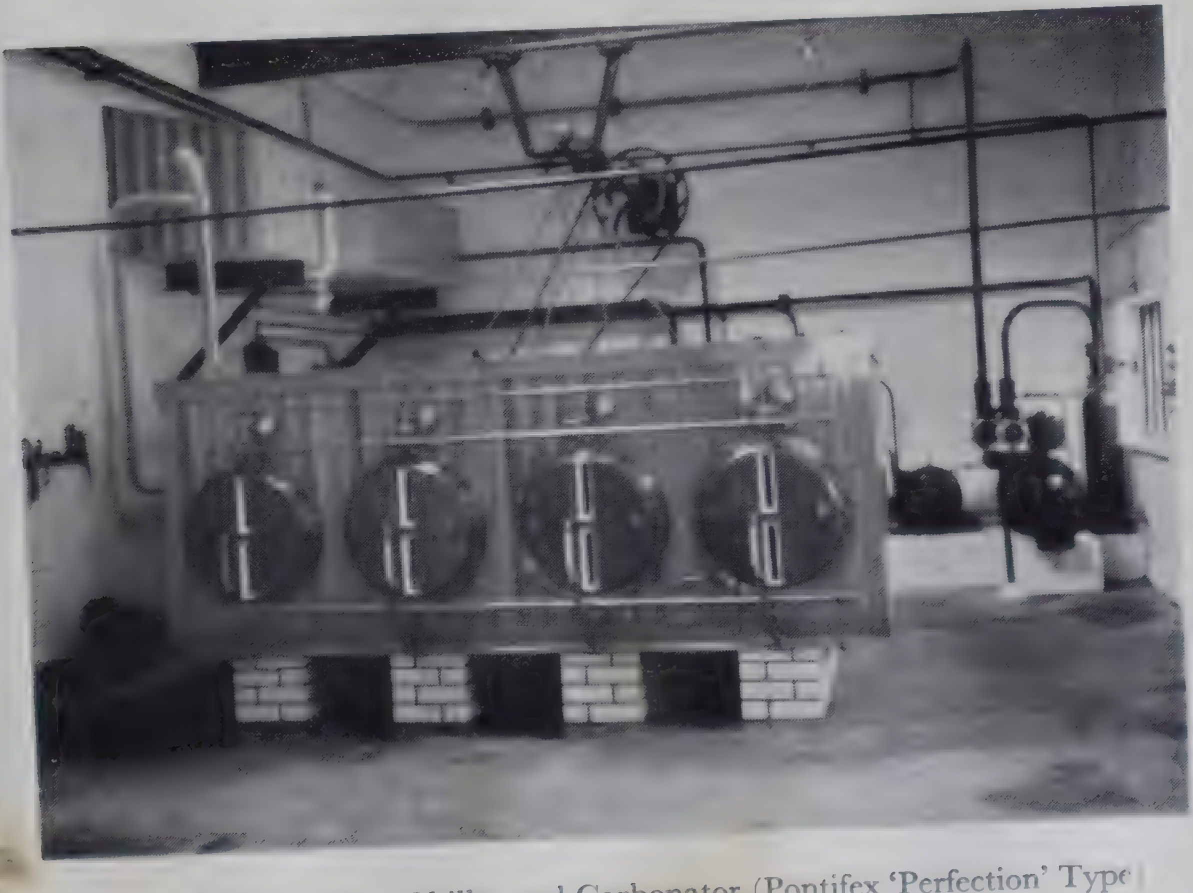


FIG. LXXIII. Cider Chiller and Carbonator (Pontifex 'Perfection' Type)

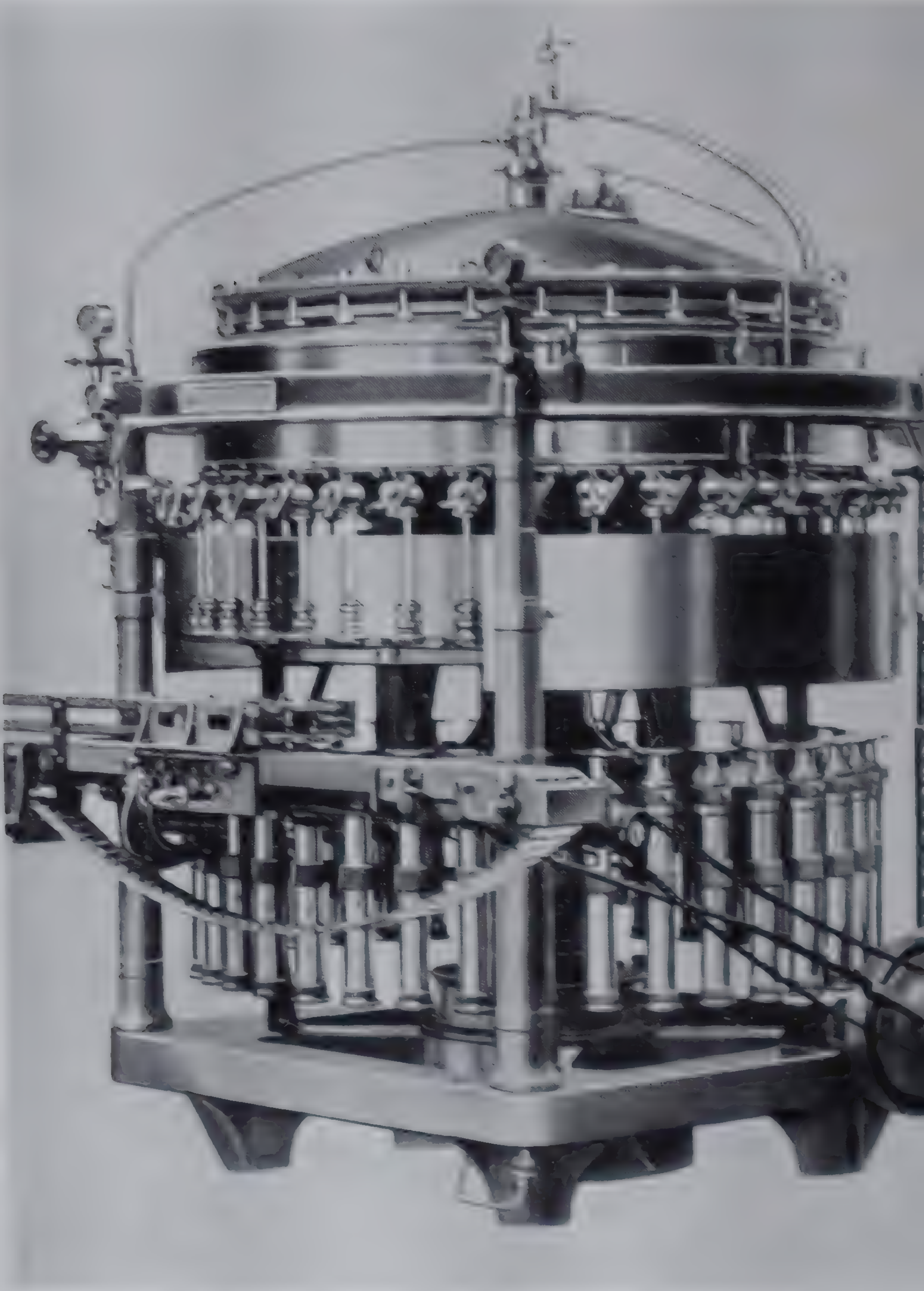


Fig. LXXIV. Pontifex 36-head Bottle Filling Machine

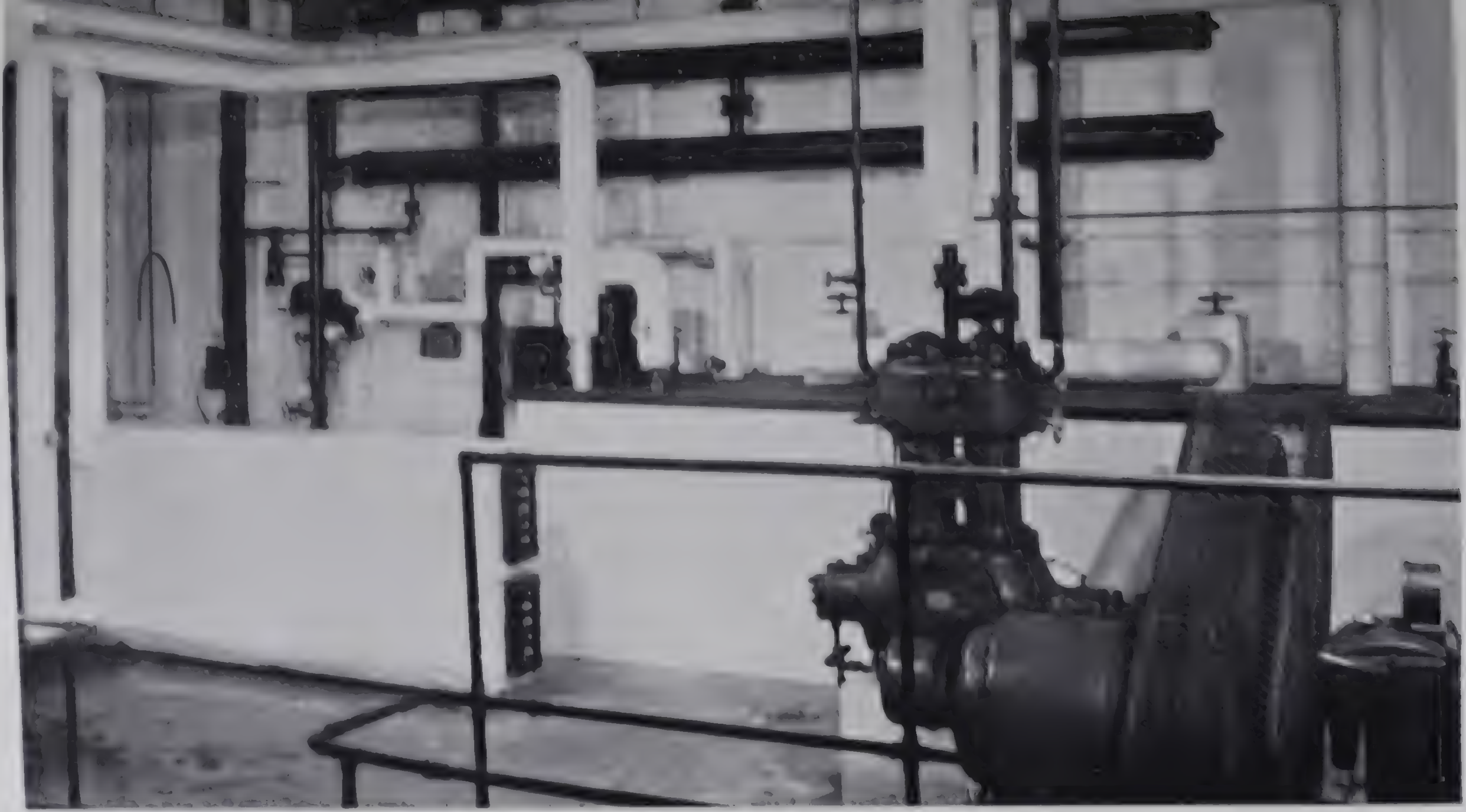
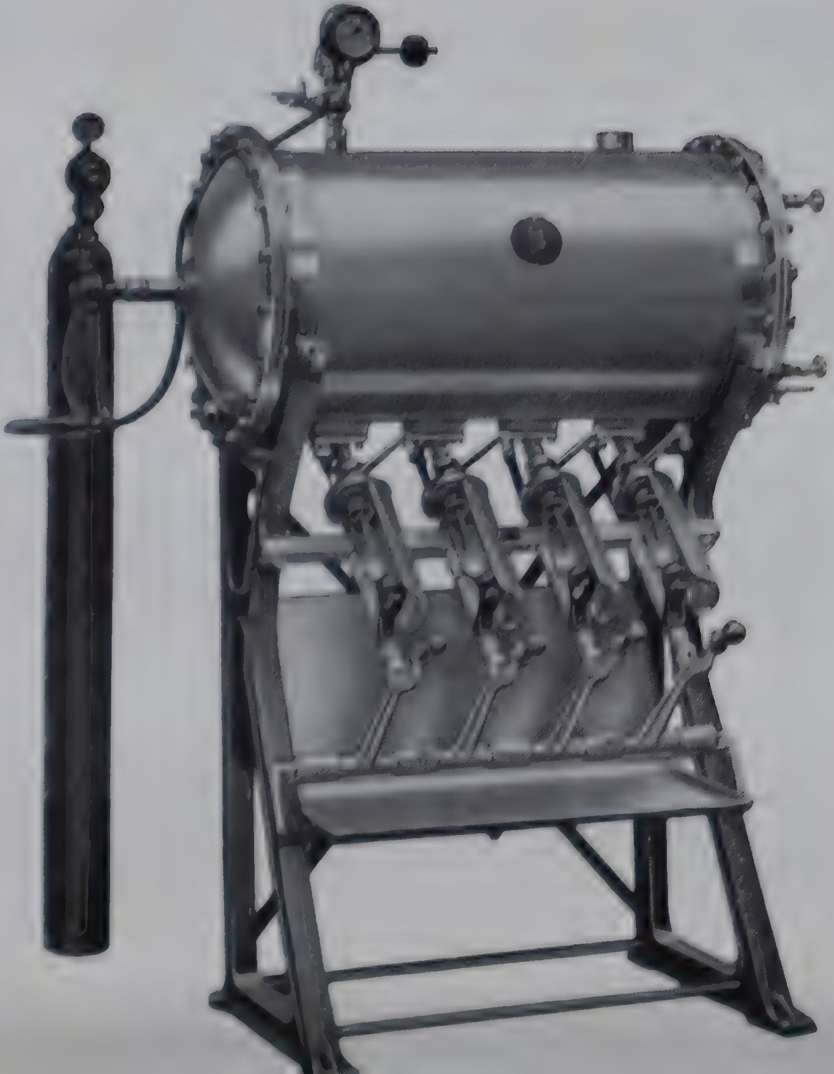


Fig. LXXV. York Shipley Brine Cooler



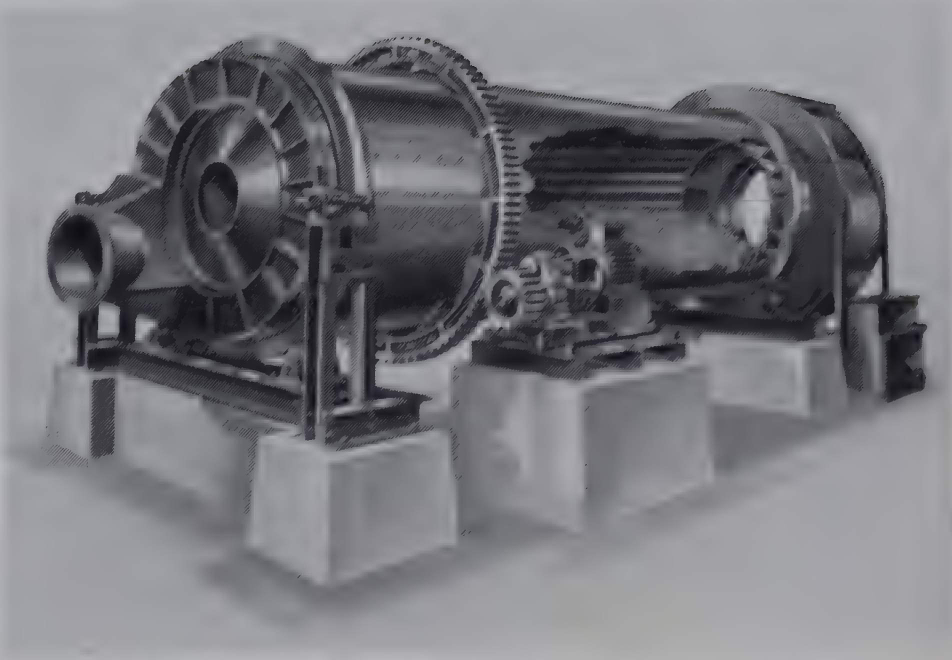


Fig. LXXXIII. Rotary Louvre Dryer (Dunford & Elliot)

d infection and this is usually achieved by covering the
of pomace with chaff and straw.

e ideal conditions for success are, therefore, to disintegrate
omace as it is collected from the press, and to build it care-
into a very dense mass to remove the maximum possible
unt of air, and finally to protect its surface from contact
air.

wo forms of ensiling are possible, one a simple but crude
edure, the other possessing much more satisfactory features.

) *Simple Silos.*—In this case, the pomace is pressed into a
ch in the ground, and is covered with straw and finally a
r of earth as for sugar beet residues. This procedure leads
onsiderable loss of pomace around the sides of the silo. The
aces of the pomace become oxidised, darken in colour and
n develop a bad taste. The formation and opening up of
silos in the winter is often difficult and wasteful if weather
ditions are inclement. If such a method is to be used, a dry,
l-drained site, free from surface water, should be chosen.
e bottom of the silo should be reinforced by a framework of
od and a rough roof should be placed over the silo to avoid
effects of atmospheric moisture. It is an added advantage
construct this simple form of silo on sloping ground in such
ay that it can be filled from the top and the silage withdrawn
m the lower surface.

b) Stone-built or Cask Silos.—Larger quantities of pomace can
preserved in casks or vats or in the angle of two walls, pro-
ing in the last case that the third side of the silo is well braced
h wooden joists to maintain a compact mass of pomace.
refully treated pomace can be kept sweet in this way for at
st six months. Excellent results have been obtained by this
thod by M. Corbiere, a stock breeder of Nonant-le-Pin, who
kes use of silos used for grass.

Only pomace that is less than twenty-four hours old should
used for silage; i.e. before any trace of acetification can be
tected. The pomace should have been produced from sound,
an apples. Fine disintegration of the pomace is essential to
tain a homogeneous mass in the silo. Abnormally high mois-
re contents in the pomace are no disadvantage and good re-
lts can be achieved by a moderate watering of the product
ilst it is being disintegrated. The pomace should be lightly

forked over and placed in the silo in successive layers of 8 i thickness, and stamped down by workmen wearing clogs. Th treatment ensures the complete expulsion of air from the mas and layer on layer is built up in the same way.

Layers of salt may be interspersed between the pomace, bu this is not absolutely essential; instead, one can use barley husk which are not digestible in the dry state. Salt may be used a the rate of 0·5-1·0% of the weight of pomace. Proportions a high as 7-10% (as recommended by Houzeau) are too high an have no additional value.

The completed silo is finally compressed and covered wit straw. A more robust covering is also desirable so that birds ma be prevented from disturbing the silo by searching for the pip to which they are extremely partial.

Perfect results are obtainable by this procedure, and the loss on the base and sides of the silo are insignificant compared wit the total weight of the material. When the silage is needed fo consumption, the silo should be opened at one end only an the feeding-stuff removed daily by neatly removing regular sec tions with a spade or pomace cutter.

Chemical Changes in Pomace during Ensilage.—Warcollier ha examined the changes that occur during the ensilage process t determine the nutritional value of the silage. This investigatio was undertaken at the instance of the Military Authorities dur ing the First World War in view of the need of the French Arm for additional feeding-stuff for horses to supplement the dwind ling supplies of fodder and oats. The first experiments wer carried out in large closed glass vessels fitted with fermentatio locks to permit the escape of the evolved gases. Later experi ments in 1926-7 utilised large casks, where the pomace wa tightly compressed to avoid excessive contact with air. The fol lowing observations were made in the later series of tests.

(*a*) *Condition of Silage.*—The contents of the silos were pale i colour, similar to that of fresh pomace in a non-oxidised con dition. This reduction in colour is caused by the action of reductase on the brown oxidised form of tannin. Again, the fer mentation process in the pomace clearly leads to a condition i which reducing processes will occur. The pomace develops a agreeable aroma which attracts the animal to which it is fed

(*b*) *Chemical Transformations.*—The changes in some of th emical constituents in the pomace may be seen from Tables XX and XXXI.

ABLE XXX.—CHEMICAL COMPOSITION OF POMACE BEFORE AND AFTER ENSILAGE

	Before Ensilage	*After Ensilage*		
	Dec. 18 1926	Feb. 9 1927	April 11 1927	July 18 1927
oss in weight at 105°C., %	73·60	82·00	81·0	81·0
Ioisture (less alcohol) %	73·45	78·14	77·8	79·12
Iineral materials %	0·69	0·78	0·79	0·71
itrogenous compounds %	1·60	1·71	1·98	1·49
ats %	1·40	1·18	1·24	0·94
ellulose %	4·95	5·20	5·83	4·93
itrogen-free extract Sugars %	9·60	0·62	0·51	0·45
Non-sugars %	8·16	8·51	8·65	10·48
otal acidity (malic) %	0·188	0·713	0·762	1·14
olatile acidity %	Traces	0·285	0·298	0·358
lcohol by weight %	0·149	3·86	3·2	1·88

ABLE XXXI.—CHEMICAL COMPOSITION OF POMACE BEFORE AND AFTER ENSILAGE

(Calculated on moisture-free basis)

	Before Ensilage	*After Ensilage*		
	Dec. 18 1926	Feb. 9 1927	April 11 1927	July 18 1927
Mineral materials %	2·61	3·62	3·57	3·39
Nitrogenous compounds %	6·42	7·88	8·94	7·12
Fats %	5·27	5·45	5·61	5·36
Cellulose %	18·66	23·96	26·49	23·56
Nitrogen-free extract Sugars %	35·52	2·83	2·29	2·15
Non-sugars %	31·52	56·26	53·10	58·42
	100·00	100·00	100·00	100·00

The most notable changes are concerned with the sugars and nitrogenous substances. The sugars almost completely disappear as a direct result of fermentation, but alcohol, volatile acids and ethers are formed at their expense. The albuminoids are degraded to amides and amino acids with correspondingly lower nutritional values. Table XXX shows that the ensiled pomace contains more moisture than the fresh product. This increase in water content can only be explained by assuming that certain organic compounds break down with consequent formation of water.

The alcohol content of the silage is a function of the amount of sugar in the fresh pomace. During ensilage, the alcohol content diminishes as a result of the action of oxidative bacteria which convert the alcohol into acetic acid.

The second table also indicates the almost complete removal of carbohydrates from the pomace. Those sugars which remain after fermentation are pentoses and are formed as the result of the degradation of pectic substances. The other constituents given in the table show increases during ensilage. Cellulose and nitrogen and sugar-free extracts increase to an appreciable extent—this being consequent upon the loss of sugar compounds.

The nutritional value of the silage is slightly less than that of the fresh pomace, but its digestibility shows such an improvement that the stock accept it with avidity.

Utilisation of Fresh Pomace Silage for Distillation.—In years of heavy crops of apples, it is usual to produce only pure-juice ciders and the pomace so obtained has a high sugar content and is suitable for the production of cider for distillation. Should there be insufficient vessels available for this process, the pomace itself can actually be distilled.

This distillation of pomace, whilst not widely practised in France, is favoured in the Rhineland and Switzerland, although the products of distillation are far from possessing the qualities of eaux-de-vie. This particular process was operated on a very large scale in France in 1917. The pomace should only be once-pressed and should retain 5-7% sugar. The fresh material must be ensiled at once in stone silos or silos sunk into the earth. They should be trapezoid in shape with a 10 ft. base and a depth of 3 ft. 9 in. The surface of the silo should be protected with strong paper and a thick layer of earth; rain water should be taken away by a system of trenches surrounding the silo. If the pomace has been placed in the silo in a perfectly fresh condition and maintained there in an anaerobic state, the sugars will be converted into alcohol during the ensiling process.

A faulty process will produce from the sugars various materials such as acetic, propionic and butyric acids, as well as certain obnoxious compounds.

Pomace which has been in the silo for two months usually contains 3·86% by weight of alcohol, and will provide by distillation 10 gallons of pure alcohol per ton of pomace.

Commercial distilleries can produce 7-9 gallons of pure alcohol per ton of apple pomace, or 6¾ gallons for pear pomace. The method of distillation adopted for the treatment of pomace is described in a later chapter.

Pomace as a Manure.—The analysis of fresh apple pomace for certain essential manurial constituents is given below, the figures having been obtained by various authorities.

	Houzeau	*Lechartier*	*Aubin*	*Warcollier*
Water % - -	80·00	75·00	—	74·00
Nitrogen % -	0·14	0·22	0·28	0·25
Phosphoric acid %	0·052	0·077	0·09	0·085
Potassium % -	0·155	0·256	0·26	0·204
Calcium % -	—	0·060	—	0·080

Warcollier recommends the use of a compost made from apple pomace for the manuring of cider orchards or arable land.

TRANSLATOR'S ADDENDA

Since 1928, the importance of finding improved methods for the utilisation of fresh apple pomace has lessened to a considerable extent, largely because of the increased demand for apple pectin which has created a considerable shortage of the dried pomace. In all countries where apples are pressed to remove the juice, attempts have been made to arrange either for individual factories to be supplied with driers or for a central drier to serve a group of smaller factories and farm cider-makers. In certain areas, owing to the scattered situations of the small installations, it has been found difficult to arrange for the whole of the pomace output to be dried, and in these cases it is still usual for farmers to feed the pomace in a fresh condition to stock. Modern practice suggests that from 10-30 lb. represents the useful limits of pomace to feed per head per day to dairy cows. Its food value is rated at about twice that of roots, but it is undoubtedly an advantage to introduce some sharps or middlings with the pomace. Practically no information has been obtained since the publication of Warcollier's book regarding the ensilage of wet pomace. One war-time effort was made in England to popularise this procedure, but the results were not sufficiently satisfactory to warrant large scale production. The details of these experiments are given in a paper by Charley, Ling and Smith in the Long Ashton Report for 1942, p. 101. During the 1939-45 war, various attempts were made in England to despatch wet pomace over considerable distances to centrally placed drying machines. Some success was achieved, but it was not possible to obtain satisfactory results without sulphiting the pomace and arranging for very speedy transport between the farm and the factory.

CHAPTER XXVI

DRIED APPLE POMACE

THE production of a stable form of apple pomace has become a necessity for all cider factories of any appreciable size, if only on account of the difficulties involved in the handling of large quantities of the material in a wet form. Dried pomace has a considerable economic value when used as a stock feed or extracted for confectionery purposes. No matter what use is to be made of the pomace, the moisture content should not exceed 13-14% to ensure safe storage over a long period.

Pomace Driers

The economic production of dried pomace for stock feeding is best effected by the use of drying machines heated by direct firing, for their thermal efficiency is naturally greater than machines heated by steam or by hot air. The most usual form of drier with direct heating is the Vernon heater. The drier is composed of a horizontal rotating steel cylinder, fitted internally with several series of paddles which disintegrate the pomace and move it progressively forward through the rotating cylinder. The drying is effected by a current of hot air produced by a furnace at one end of the machine; the temperature of the hot air can be adjusted by admitting with it a regulated quantity of cold air.

The wet pomace and the hot air circulate in the same direction within the rotating cylinder. The ingoing pomace with 70-75% of moisture is contacted by very hot gases at 300-550°C. whilst the outgoing material (12-13% moisture) is accompanied by the heating gases at 120°-150°C. which have become saturated with water vapour.

For this type of plant, three men are needed; one to feed the fire, one to feed the wet pomace, and a further man to fill the dried product into sacks. For the production of 1 ton of dried pomace, the plant consumes 8-11 cwt. of fuel. In general, 1 lb. of coal will evaporate 6-8 lb. of water. The thermal efficiency of the type of drier under discussion is about 55%, which is very satisfactory and approaching that of steam drying machines.

There is a slight destruction of sugars during the drying process.

The rotating driers are most suitable for cider factories and distilleries producing at least 5-7 tons of fresh pomace per twenty-four hour day. Other driers are also available. Amongst French types may be cited the Huillard (using waste heat from factory boilers) and steam driers (Fouché type). Pomace dried by steam is light in colour as the temperature to which it is exposed is generally less than 100°C. Such products are particularly suitable for confectionery purposes.

No matter what method of drying is employed, the process cannot be economical unless well-pressed fresh pomace is available; i.e. with a moisture content between 65-70%. As a general rule, fresh pomace from French cider factories retains 72-75% moisture, from distilleries 80% moisture, from farm cider equipment 80-85%, and pomace from the diffusion process 90%.

To obtain 100 units of weight of dry pomace with 12% moisture, it is necessary to use:

352	units of	fresh pomace	with	75%	moisture
440	,,	,,	,,	80%	,,
586	,,	,,	,,	85%	,,
880	,,	,,	,,	90%	,,

This corresponds to the removal of:

252	units weight	of water	from	a fresh	pomace	containing	75%	water
340	,,	,,	,,	,,	,,	,,	80%	,,
486	,,	,,	,,	,,	,,	,,	85%	,,
780	,,	,,	,,	,,	,,	,,	90%	,,

If it is assumed that one pound of coke evaporates 6·2 lb. of water, it is necessary to use the following amounts of this fuel to produce 1 ton of dry pomace:

0·4	ton fuel	for fresh	pomace	containing	75%	moisture
0·55	,,	,,	,,	,,	80%	,,
0·78	,,	,,	,,	,,	85%	,,
1·26	,,	,,	,,	,,	90%	,,

When pomace from hydraulic presses is available, it is usual to obtain 1 ton of dry pomace from 3·5 tons of fresh pomace. But it is known that 1 ton of apples provides $\frac{1}{4}$ ton of fresh pomace. Hence, 1 ton of apples will, on an average, yield 1·4 cwt. of dry pomace with 12% moisture. In practice, a yield of 1·2-1·3 cwt. is usual.

The figures in Table XXXII were obtained at the Cider Research Station at Caen on dry pomaces provided by movable cider presses (the pomace having been re-soaked before its final pressing).

TABLE XXXII.—ANALYSIS OF DRIED APPLE POMACES
(all figures as % by weight)

	No. 1	No. 2	No. 3	No. 4
Moisture content	11·4	12·1	13·2	12·5
Dry matter	88·6	87·9	86·8	87·5
Ash	3·7	4·0	3·5	3·8
Nitrogenous substances	4·7	4·5	4·2	5·0
Fat	4·7	4·0	4·0	3·8
Cellulose	20·0	18·2	19·1	21·0
Nitrogen-free extractives	55·5	57·2	56·0	53·9

Dried pomace produced in cider factories contains 12-13% of sugar, whilst similar products from distilleries show a range of 8-9% of sugar. The nutritional value of dried pomace can be calculated from the tables of O. Kellner. The calculations of Warcollier show that pomace No. 1 contains the following amounts of digestive materials.

	% by Weight
Protein	1·90
Fat	2·35
Cellulose	1·27
Nitrogen-free extractives	42·05

These figures show that the nutritive value of the pomace expressed as the ratio of the nitrogenous to the non-nitrogenous materials is 1/25. Thus, the pomace is unbalanced nutritionally on account of its very low nitrogen content. The ratio mentioned above should vary between 1/7-1/12 according to the species of stock to which the ration is to be fed, and to the ultimate purpose for which the animals are being raised.

The nutritive value of the above sample is 39 units, assuming that starch is given unit value for digestibility.

In general, dried pomaces have a starch equivalent equal to a good sample of hay, but the nitrogen content is always low. A mixture of 85% of dried pomace with 15% oilcake possesses a nutritive value of 43·5 units (calculated as starch) and a nutritive ratio of 1/5·8.

The French Army authorities noted the possibility of replacing some of the hay and oats by apple pomace in the ration of horses. Within limits, pomace can replace an equal weight of best hay or half its weight of oats.

Dried pomace is appreciated by cows, sheep, pigs and backyard animals. Horses and mature cows can be fed with 7-11 lb. of dried pomace daily, the ration being moistened before use. Sheep should receive not more than 1 lb. per head per day.

It is most important to adjust the moisture content of the pomace as it leaves the drier to 12-13% and it should never be offered for sale with a greater water content than 14%. The flavour and aroma should be clean and fresh and should remain in this condition throughout the storage life of the product. A perry pomace should not be mixed with the apple material to an extent greater than 5%.

Should the moisture content of the pomace rise to 14-15%, there is usually a reduction of price, but above 15% the product ceases to have any value.

Pomace-Molasses Mixtures

Dried apple pomace is most satisfactorily utilised in association with molasses. The following analyses (as % by weight) represent the composition of two of these samples, in which the pomace and molasses were mixed in equal proportions.

	No. 1	No. 2
Moisture	18·00	18·02
Nitrogen compounds	5·94	6·24
Fats	2·22	1·93
Total sugars (as glucose)	27·80	29·24
Reducing sugars	4·40	4·00
Sucrose	22·23	23·92
Crude cellulose	14·10	9·30
Ash (as sulphate)	8·00	5·94
Nitrogen-free extractives (without sugar)	24·11	30·65
Acidity in liquid phase (as malic acid)	0·55	0·45

The moisture content of the mixtures should never rise above 18%, with a tolerance either way of 2%. The sugar content should fall between 25-33%; to achieve this composition the mixture should contain between 40-50% of molasses. The pomace-molasses ration will normally possess a nutritive value of 42-44 units of digestibility.

A particularly valuable ration can be prepared from 55 parts of dry pomace, 30 parts of molasses and 15 parts of arachid oilcake. In starch equivalents the mixture is evaluated at 30 units, and it shows a nutritive ratio of 1/6 to 1/7.

The experiments of the French Army authorities previously mentioned indicate that a 50% molasses mixture with pomace can replace two-thirds of its weight of oats. For cows, 30% admixture of molasses will suffice.

Pomace-molasses mixtures are to be especially recommended as rations for working animals, on account of the energy-giving value of the sugar, but these balanced foodstuffs are also quite suitable for all farm animals. The ration should be arranged in such a way that the molasses acquired by the animals from the stock feed does not exceed the following daily amounts per 1 ton live weight of the animals concerned: horses, 4·5-6·5 lb.; ruminants, 9-11 lb.; milking cows, 4·5 lb.; sheep, 0·5 lb.

The mixing of the two constituents should be carefully performed. The molasses, with 25-27% of water, are heated to 90°C. in a steam-heated copper with a double lining. 70 parts of pomace in a disintegrated condition and 30 parts of molasses at 90°C. are introduced into a machine fitted with special rotating vanes which intimately mix the two constituents. The mixture is spread on a clean floor to a depth of 18 in., turned over with a shovel after twelve hours standing, after which the material can then be filled into sacks. The pomace-molasses mixture can be stored in sacks without taking any other precautions than preventing the access of moisture. The mixed ration should not be made up too long in advance, as losses in sugar content up to 40 per cent have been noted during a four months' storage. Three months is the maximum safe keeping period and this time should never be exceeded.

PECTIN FROM APPLE POMACE

Preparation of Pectin Extracts from Dried Apple Pomace

Apple pomace is a most valuable source of pectin, but the commercial extraction of the pectin is complicated by a number of factors. The pectin content of pomace produced in any single season from an individual factory will always be extremely variable and the actual pectic constituents will themselves vary with regard to their jellying powers. It is thus imperative that producing firms should seek to achieve those conditions which will provide the optimum yield of the specific pectic substances that possess maximum setting properties. The critical assessment of the value of any sample of pomace can only be made by treating a large, carefully chosen sample of pomace, about ½-1 cwt. in weight.

Apple pomace from the cider factories and distilleries does not contain appreciable quantities of free pectin, for this constituent of the apple will be removed by the re-soaking and re-pressing treatments. The pomace, however, does retain pectin in a combined form, this being variously known as pectose, protopectin or pectinogen. Pectin in this form is largely combined with cellulose in the cell walls of the apple. During the process of ripening, the more complex material is degraded into cellulose and free pectin (the latter being in a soluble form and passing rapidly into the juice). This degradation, however, is never complete, so that the pressed pomace will always contain a certain proportion of combined pectin, which, on hydrolysis, provides the pectin which can later be extracted from the dry pomace.

In practice, those bulks of apple pomace which contain the highest amounts of combined pectin are those that are produced from fruit milled before 'peak' maturity, i.e. from fruit that has released the minimum quantity of pectic substances during the processes of juice extraction. It can readily be appreciated that there is thus some clash of interests between the cider-maker and the pectin producer. The former should, in his own interest, utilise fruit which has become fully ripe but which will, in consequence, contain relatively high proportions of soluble pectin which will be lost by solution in the juice; the pectin producer, however, has an interest in retaining in the pomace for his own use the maximum amount of 'potential' pectin from the original fruit.

Sweet apples, milled before becoming fully ripe, contain more potential pectin than sharp fruit at the same stage of maturity. These considerations show that the pectin content of any pomace will vary according to the maturity of the fruit, the season, the variety of apple and the mechanical conditions of juice extraction and pomace drying.

Extraction of Hydrolysable Pectin

The combined form of pectin must be hydrolysed into soluble pectin by the action of heat in the presence of some chemical agent or water, the degree of hydrolysis being considerably affected by the time allowed for the reaction to take place. (Warcollier, 'Study of pectic juices, extracts from apple pomace', *Bulletin Association Française pomologique*, 1925).

In some cases certain biological enzymes are used for this purpose.

Tartaric or citric acids can be usefully employed for the hydrolysing action. For example, an aqueous solution of the pomace can be heated at 100°C. for 30 minutes with tartaric acid (the acid being used in such a quantity as to provide a strength of 0·15% in the pomace extract). Citric, sulphuric or hydrochloric acids can be used in chemically equivalent proportions to that given above for tartaric acid.

The pectic constituents of each bulk of pomace will possess their own specific character and the hydrolysis treatment will necessarily vary for each batch. If the hydrolysis is excessive, the resulting pectin will be too completely de-methoxylated and will possess only a relatively poor setting value.

Some degree of hydrolysis can be effected merely by the use of water. The conditions of the reaction must be altered and it should be remembered that a longer reaction period allows the use of a somewhat lower temperature. Warcollier states that pectins prepared by acid extraction for long keeping purposes retain their setting powers for shorter periods than those extracted by water alone.

As soon as the hydrolysis process is completed, the hot extract should be filtered or centrifuged. The clarified extract should then be evaporated in vacuo to 7-8° Brix. At this stage the liquor should contain between 5-10% of pectin, in addition to variable amounts of sugars, tannin, acids, minerals, etc. Milk evaporators can be effectively used for this concentration process.

The exhausted pomace can either be pressed or centrifuged, the latter for preference. The residues, after drying, can be used as a stock feed but if this is done admixture with molasses is highly desirable. The extracted pomace is naturally slightly lower in extractives than the normal type of pomace.

Stability in the pectin extract is assured by pasteurisation at temperatures not exceeding 70°C. The extract can be transported in metal vessels, casks or glass carboys.

The manufacture of pectin is legally complicated by the vast number of patents which exist in America, Germany, France or Italy, etc.

Pectin Jellies

These jellies are formed as the result of the application of heat to a mixture of suitable proportions of sugar, acid and pectin. The jellying power of a pectin extract is directly related to the original degree of methoxylation of the pectin and the preservation of its initial constitution throughout the hydrolysing process.

Although it is impossible to give a recipe for pectin jellies which will be applicable in all cases the following proportions will generally suffice to provide a jelly: water, 40 parts; sucrose, 58 parts; pectin extract, 17 parts. The mixture should be boiled down to a final volume of 100 parts. If the pectin extract has been obtained by pure water extraction, acid must naturally be introduced into the jelly mixture. Firm jellies can be produced with 0·5-1·0% of pectin in the final product. An average analysis for such a product will show the presence of 60% of sugar and 1·0% of pectin, and a *p*H value of 3·0. If tartaric acid is used, the acidity of the jelly will vary between 0·5-1·0%.

Jellies are made by boiling the pectin material with water and then adding the sugar and acid constituents. A well-made jelly should be firm and when cut with a knife the edges should remain well-defined and should not run; there should be no sign of 'weeping' on the surface; should the jelly possess a lumpy consistency or the surface be hard and wrinkled, too much pectin has been used.

The French regulations of 10th December 1910, modified by a decree of 16th December 1925, allow the use of pectin extracted by acid hydrolysis (i.e. tartaric, citric, sulphuric, hydrochloric acids) for confectionery purposes, with the proviso that the finished product must not contain more than traces of the acid used in the extraction process. Pectic materials which retain more than 1·0% of tartaric acid may not be used in the preparation of confectionery unless the designation of the confection is immediately followed by the term 'fantaisie'.

Pectin in Dry or Powdered Form

In 1928 powdered pectin was not an article of commerce. The method of experimental production at that time was to precipitate the pectin with alcohol and to purify it by washing with ether or by a further precipitation with acetone. These solvents or precipitants must be recovered if the process is to be economically sound. Warcollier gives the following analysis for a sample of dried pectin carried out by himself.

Moisture - - - -	11·38%
Pectic substances - -	84·0%
Reducing sugars - -	Traces
Tannin - - - -	Nil
Acidity - - - -	1·47%
Ash - - - - -	3·15%

TRANSLATOR'S ADDENDA

The importance of producing larger quantities of pectin has led to very great increases in the quantity of apple pomace being passed through drying machines. In general, their operation is the same as that mentioned in Warcollier's book. Fig. LXXXIV gives an illustration of one of the most up-to-date machines now being produced (Richard Simon & Sons Ltd.) which has an extremely large output. This machine is generally fitted with an exhaust fan which sucks the dried pomace flowing from the machine and blows it through a very considerable distance until it is sufficiently cool to be filled direct into sacks, using a machine with counter-balanced weights and a counter which automatically checks the number of sacks filled in any given time.

One of the most efficient and successful types of pomace dryers is the Rotary Louvre dryer made by Dunford & Elliott (Sheffield) Ltd. Fig. LXXXIII. Tests made by the Department of Agriculture Laboratories in the United States of America, where several plants have been installed, have shown that this type of dryer gave a pomace containing 30% to 50% more pectin than that dried by any other method. Single or double pressing of the peel, cores and cull apples is essential to produce a pomace with a moisture content of about 60% to 70%, but the cost of this additional pressing is soon recovered in the increased yield of juice. The pressed pomace is disint grated in a hammer mill and passed to the dryer where i water content is reduced to below 12%. It seems to be gene ally agreed that coke is the best fuel to use for the heati medium because the products of combustion have a bleachi effect and help materially to preserve the pectin content, th producing a higher grade of pomace. The average fuel co sumption is about 1 lb. of coke for every three pounds of dri pomace produced. No labour is required beyond occasion supervision, the plant being fully automatically controlled.

By far the greater part of the pomace produced is used f apple pectin, although certain quantities may still be useful employed in the manufacture of a concentrated stock fee The problem here is the low nitrogen and fat content of th product, and it is essential that it should be blended with su able constituents to provide a balanced ration.

Knott, Hodgson and Ellington (1) have produced data fro which the following general conclusions have been drawn.

(i) Groups of cows fed with dried apple pomace produced a proximately 93·5% as much milk as the dried beet pulp grou

(ii) Moistened dried apple pomace can be fed at the rate 3 lb. per 100 lb. live weight daily. The pomace should be mo tened with 2·5 times its own weight of water.

There is some usefulness in the pomace residue left after t extraction of pectin. It is higher in crude protein and ether e tract and lower in available carbohydrate than dried app pomace.

Recent attempts that have been made to transport poma over a considerable distance before drying it have been report by workers at the Long Ashton Research Station. Charley *et* (2) noted very considerable losses in jellying power when th wet, twice-pressed pomace was stored either in heaps of disi tegrated pomace or in a vertical erection of compressed sla as taken from the cloths; this loss was noted over a period of s days, but 50% of the total loss occurred during the fi twenty-four hours. The destruction of pectin could be a preciably retarded by the admixture of 1,500 p.p.m. of sulph dioxide in the pomace, and this amount of preservative h been used on several occasions for the bulk transportation pomace from small factories to central drying stations. In th nce of the use of any preservative, the tests showed that of the setting value of the pomace was lost in one day, and ther 20% at the end of six days. Burroughs, Kieser, Pollard Steedman (3) examined the matter by studying the reac- s occurring in the storage of wet pomace in small containers. as found that approximately the same preservative effect obtained from sulphur dioxide additions which ranged veen 250 to 1,500 p.p.m. In the circumstances of the tests, a slight loss in jellying power was noted in the pomace r 7 days, whilst a considerable loss only occurred after 13 s' storage. Immature fruit gave pomace with the highest y strength.

e Extraction and Evaluation of Pectin from Fruit Residues

Until shortly before the last war, the precise methods of pectin raction from apple and citrus residues were hedged about h a voluminous patent literature and most manufacturers imed to be using secret processes of their own. The unsealing his closed book is largely due to the publication by American rkers of new methods for the more efficient extraction of ctin, and by British workers of the scientific principles in- lved in these and other procedures. Much more prominence s been given to citrus than to apple pectin, and in view of the mplexity of the whole subject, caused by the intricate inter- tion of the various factors affecting pectin extraction, it is propriate in a book of this nature to make reference to only few of the relevant publications. A full study of the whole bject can be undertaken from the references given in the pers referred to below.

The Western Regional Research Laboratory (Albany, Cali- rnia) published details in 1943 (4) of a method for extraction pectin from apple pomace. The cold water soluble substances specially sugars and heavy metals) were removed by treat- ent of one part of pomace with ten parts of water at 50°C. for alf an hour with continuous stirring, the process being repeated least once. The drained leached pomace was mixed with ater to the extent of ten times the weight of the dry pomace nd the liquor brought to *p*H 2·8 with sulphuric acid. The mix- ire was boiled for one hour by steam. The pressing of the pulp as facilitated by the addition of 0·5% by weight of paper pulp

and filter aid. The extract was cooled to 50°C., the pH adjuste
to 4·5 with sodium carbonate, and starch-decomposing enzym
added at the rate of 0·1-0·2% by weight of dry extract for 1-
hours. Citric acid was then added at 0·3% concentration b
weight until the pH fell to 3·0. The temperature of the liqu
was again raised, this time to 80°C., and before filtration su
phur dioxide was added just to saturation. The liquor thus pr
pared and clarified was concentrated in vacuo to one quarter
its initial volume. At this stage, the product was usually
5-grade pectin extract. (The modern definition of pectin 'grad
is the number of units of sugar that can be made into a jelly
standard firmness by the pectin in one unit of extract und
standard acid conditions.) The extract was flash-pasteurised
85°C. and packaged hot into suitable containers.

In recent years, many workers have studied the improveme
in yield of pectin which may be achieved by extraction in th
presence of sodium polymetaphosphate or polyphosphate. The
chemicals possess the power of 'sequestering' calcium ions an
thus preventing some of the loss of pectin in the extract whic
had previously been noted when hard water was used for ex
tracting purposes (5, 6). Mottern and Hills showed that the us
of polyphosphates gave a 25% increase in yield of pectin, base
on jelly power of the extract. McCready *et al.* (7), working wit
citrus peel, found that the effectiveness of these compounds in
creased with increase of pH to at least 3·5. Their usefulness a
pH values near 2·0 was nil, a fact of considerable importan
since it is known that maximum jelly strength is obtained onl
when citrus peel is extracted at this low pH.

The evaluation of pectin extracts or pectin in solid form can
not adequately be effected by a mere chemical analysis, and i
consequence physical means are generally adopted. There i
even now no commonly accepted method in all countries, an
each firm adopts its own particular technique for assessing th
jelly strength of its products. The first method to be used intro
duced a technique due to two British workers, Lockwood an
Hayes (8) for gelatin jellies. This was followed by the Tarr
Baker Delaware tester (9) which measured the breaking poin
of a jelly. The pressure required to force a plunger (hypodermi
syringe) through the surface of a test jelly is measured in cm. o
water. This method avoids errors that may be introduced b

riations in elasticity in the jelly. The B.A.R. jelly tester (10)
termines the elasticity modulus of the jelly by measuring the
essure needed to rotate a standard sized vane through a pre-
etermined angle when immersed in a jelly under strictly stan-
ardised conditions. More recently, Cox and Higby (11) intro-
uced their version of the Ridgelimeter, based on the principle
iginally suggested by Lockwood and Hayes. The new modi-
cations provided by Cox and Higby have the following advan-
ges, according to the authors: the jelly surface is not ruptured;
ne jelly is not strained beyond its elastic limit; jellies of com-
nercial firmness can be tested; the tester is of standard con-
truction and can be made in any tool shop; and the instrument
neasures jelly firmness accurately and reproducibly. The ori-
inal procedure of Lockwood and Hayes was to measure the
ag or slump when a test jelly was removed from its supporting
ontainer and inverted on a level surface. The new modification
tilises jelly glasses of definite depth and a measuring device
which gives the per cent decrease in height by a direct measurement (Fig. LXXXV).

An even more recent contribution to the literature of this subject is that of Mottern and Karr (12). An extract of apple pomace is made under standard conditions and from this is prepared a 65% sugar jelly by a given procedure. The jelly is tested by the Delaware instrument. The results which can be expressed in terms of 'grade' represent the percentage of 100-grade pectin available in the pomace.

Cheftel and Mocquard (13) have provided information regarding a new apparatus for the continuous recording of the rheological properties of jellies, and the behaviour of these systems in comparison with gelatin and agar gels has been observed and discussed. An interesting point is raised regarding the possibility of the peculiar rheological properties of high sugar-high methoxyl pectin gels being responsible for some of the organoleptic qualities of this type of jelly:—'while agar jellies are frankly unpalatable on account of their toughness, and gelatin jellies are edible only after they have warmed up and melted away in one's mouth, high sugar-high pectin jellies possess a softness of their own which is probably an important factor in the freshness and pleasantness of fruit preserves'.

It may be interesting to quote a further sentence from the authors' paper: 'If we do not give a more detailed descripti of our recording jelly tester, it is because we do not now thi it is the right instrument to use and, in fact, we have arrived the conclusion that all measurements of this kind, be they aut matically recorded or not, are fundamentally unsound wh made on high sugar-high methoxyl pectin gels of the type us ally encountered in fruit jams and jellies. As we see it, the on merit of our instrument is that it has allowed us to reach th conclusion, a better jelly tester still remaining to be devised. .

General

For a general review of the subject of pectin jellies, the thr contributions to the subject given at the end of the referenc may be consulted (14, 15, 16).

REFERENCES

(1) Knott, J. C., Hodgson, R. E. and Ellington, E. V., *Bull. Wash. Agric. Ex Sta.*, 1932, p. 270.

(2) Charley, V. L. S., Burroughs, L. F., Kieser, M. E. and Steedman, J., *A Rept. Long Ashton Res. Sta.*, 1942, p. 89.

(3) Burroughs, L. F., Kieser, M. E., Pollard, A. and Steedman, J., *ibid.*, 194 p. 136.

Pectin Extraction

(4) West Reg. Res. Lab. (U.S. Dept. Agric.), Information Sheet on the Prepar tion of a Liquid Apple Pectin Concentrate (AIC-28), Sept. 1943.

(5) Baker, G. L. and Woodmansee, C. W., *Fruit Prod. Jnl.*, 26(6):164-5, 185:194

(6) Mottern, H. H. and Hills, C. H., *Ind. and Eng. Chem. (Ind.)*, 38(11):1153- 1946.

(7) McCready, R. M., Shepherd, A. D. and Mackay, W. D., *Fruit Prod. Jn* 27(2):36-39:1947.

Pectin Evaluation

(8) Lockwood, H. C. and Hayes, R. S., *J. Soc. Chem. Ind.*, 50:145T-151T:193

(9) Baker, G. L., *Fruit Prod. Jnl.*, 17:329:1938.

(10) Campbell, L. E., *J. Soc. Chem. Ind.*, 57:413-7T:1938.

(11) Cox, R. E. and Higby, R. H., *Food Ind.*, 16:441:1944.

(12) Mottern, H. H. and Karr, E. E., *Fruit Prod. Jnl.*, 25(10):292:1946.

(13) Cheftel, H. and Mocquard, J., *J. Soc. Chem. Ind.*, 66:297-9T:1947.

General

(14) Branfoot, M. H., *A Critical and Historical Study of the Pectic Substances of Plant* Spec. Rep. Food Invest. Bd., London, 1929, No. 33.

(15) Hinton, C. L., *Special Food Investigation Board* (Dept. of Scientific an Industrial Research), 1939, No. 48.

(16) Cheftel, H., *Utilisation Industrielle des Fruits, Confitures, Marmelades et Gelée* Établs. J.-J. Carnaud et Forges de Basse-Indre, Paris: November 1943.

CHAPTER XXVII

UTILISATION OF OTHER RESIDUES

wo other residues call for mention, namely apple seed and the es deposited in the keeving or fermentation of the juice.

Apple Seeds

The seeds from the pomace residues are used for growing of ocks to be grafted with selected varieties. This business is rgely confined to French, American and English nurserymen. n 1928, apple seed was sold at 400-600 f. per 100 kilogrammes 3½d.-5¼d. per lb.), whilst pear seed was worth 800-1200 f. for he same quantity (7d.-10½d. per lb.).

It has often been considered that an equally profitable means f utilisation of the seeds would be to extract their oil. War-ollier in his treatise on cider apples showed that dry apple seeds ontain 25% of their weight of fixed oil of a quality at least qual to that from raisin seed.

The Co-operative installations of the south of France deal vith the extraction of the seeds of raisins at the rate of 2½ tons per day; such a quantity of seeds from apples would call for the provision of 500-600 tons of apples, but sufficient data is not yet available to determine whether the seed is worth more for oil production or for sale to nurserymen. In Warcollier's view, production and other costs are in favour of the latter procedure.

Lees

Deposits that are formed on the bottom of casks and vats are referred to as 'lees'. They are composed of a wide variety of solid materials which separate during the various processes of cider-making. This term may also be used to refer to the solid matter forming a 'head' during the keeving process. Lees may be distinguished as those emanating from the first or later racking treatments.

Lees from the Keeving Process.—Lees formed in this way are composed of particles of pulp or skin, apple seeds, other adventitious materials, starch granules, coagulated pectic compounds more or less coloured by oxidation, as well as nitrogenous ar mineral substances. Such lees also contain a variety of micr organisms, such as moulds, wild yeasts, mycoderma, bacteri true yeasts, etc. Lees of this type should be collected immed ately they have formed and treated with ¾-1½ oz. sulphuro acid per 100 gallons. The addition of this preservative will su press irregular fermentations and allow a normal alcoholic fe mentation to proceed. The clear liquid that forms as a result this treatment can be withdrawn from a series of cocks at d ferent levels and utilised for distillation.

Well-equipped factories are provided with filters specially d signed to clarify the lees. Such filters are designed by the Fren firms of Gasquet, Philippe and Simoneton. The filtered juic may then be returned to the keeved liquors.

On the farm, the lees may be clarified by passing the through a thin layer of pressed pomace that has been disint grated to a fine condition. Alternatively, the lees may be filter through one or more very clean sacks suspended over a clea vessel. In this case the liquor should later be distilled.

The exact quantity of lees which can be anticipated from given quantity of apples is quite impossible to estimate in a vance. Warcollier has shown that the volume of the lees vari chiefly with the nature and extent of the pectic coagulatio Sometimes the lees are so thick that they form an almost fir jelly; on other occasions they are less viscous and become gra ular in consistency. The volume that can be expected is 5-10 of the volume of the cider.

Lees from Racking Processes.—The most extensive deposition lees occurs as a result of the main fermentation process, and second racking is needed to remove the deposit from the cide If the keeving has succeeded in its essential purpose, the mai body of the lees will consist merely of yeasts and pectin com pounds. Such lees, if microscopic examination establishes the microbiological purity, can be utilised for inoculating other pro ducts with cider yeasts. Alternatively, these lees may be mixe with cider and distilled into excellent cider brandies.

Third rackings provide only limited quantities of lees. The may be filtered by one or other of the ways mentioned pre viously. The clarified liquors may be distilled and the soli residues are used for compost.

There are naturally very considerable variations in the ounts of lees produced by the racking of individual ciders er they have undergone their main fermentation. The nearest neralisation that can be given suggests that the lees from ree consecutive rackings constitute 10% of the volume of the iginal juice; of these lees, half the quantity will be of the heavy pe, whilst half will comprise the light variety.

The total volume of lees may sometimes constitute 15% by lume of the original juice. This is much too high a figure, and diminution in the loss of volume should be effected by some rm of filtration. These general data refer to juices produced y hydraulic expression from the milled fruit. Juices from the ffusion process do not develop such extensive lees (Séguin and ailheret estimate the amount at less than 4%) on account of ie pectin coagulate being formed during the maceration pro-ess and remaining in the pomace.

The lees produced from poor fruit or as a result of abnormal rmentations should be completely discarded.

Filtration of Lees.—Warcollier examined the various methods f clearing the lees in such a way that the filtered or clarified roduct could be immediately returned to the cider from which originated. The ideal machine should be continuous in action nd thus such machines as the filter-centrifuge (Hignette) and he Sharples supercentrifuge are not of optimum use. The latter nachine has given excellent results with cider lees and the only lisadvantage is that the solid phase is collected in the bowl and ieeds to be removed from time to time, thus causing the process o become discontinuous.

CHAPTER XXVIII

DISTILLED CIDER PRODUCTS

(*Eaux-de-vie de cidre: Cider Brandy*)

THE production and consumption of products distilled from cider is shown in the two tables which follow.

TABLE XXXIII.—PRODUCTION OF DISTILLED CIDER PRODUCTS IN 1927 IN FRANCE

Producing Area	*Absolute alcohol (in gallons) provided by the distillation of apples, pears, ciders, perries and their lees*		*Total production in gallons*	*Effective number of*	
	Commercial Distillers	*Farm Producers*		*Commercial Distillers*	*Farm Producers*
Manche	1,195,651	238,859	1,434,510	90	50,925
Ille-et-Vilaine	1,211,620	193,377	1,404,998	93	72,895
Calvados	771,584	253,132	1,024,716	99	20,157
Eure	848,410	145,607	994,017	57	22,737
Côtes-du-Nord	463,303	64,604	527,908	24	42,604
Orne	249,400	209,055	458,455	53	37,070
Morbihan	258,080	98,708	356,789	7	54,858
Seine-Inférieure	292,510	56,995	349,506	42	17,616
Mayenne	138,566	161,077	299,643	22	45,974
Sarthe	67,443	168,263	235,706	34	63,669
Somme	209,558	2,358	211,917	1	1,068
Eure-et-Loire	70,080	31,611	101,691	5	11,479
Loire-Inférieure	22,935	59,415	82,350	10	37,101
Haute-Savoie	27	66,875	66,902	1	32,907
Deux-Sèvres	56,061	5,625	61,687	1	3,928
Char-Inférieure	47,109	309	47,418	1	198
Maine-et-Loire	—	45,544	45,544	—	24,567
Loiret	19,429	22,468	40,798	9	11,021
Yonne	1,594	34,498	36,092	2	20,204
Finistère	1,064	33,879	34,944	14	14,810
Aube	2,099	20,512	22,611	1	9,990
Seine-et-Marne	—	21,560	21,560	—	11,705
Seine-et-Oise	70	19,719	19,789	10	9,316
Ardennes	34	10,813	10,848	1	5,814
Total for principal French Departments	5,925,534	1,964,873	7,890,407	577	621,722
Total for other French Departments	153,730	200,105	353,836	69	148,751
National total	6,079,264	2,164,979	8,244,243	646	770,473

TABLE XXXIV.—CONSUMPTION OF POTABLE ALCOHOL FROM 1916 TO 1925

Year	*Millions of gallons*	*Year*	*Millions of gallons*
1916	20	1921	17
1917	17	1922	20
1918	13	1923	22
1919	18	1924	21
1920	19	1925	22

In the period 1897-1907, the average production of cider and pear brandy (expressed as pure alcohol) was 941,000 gallons; in 1912, production had reached 1,977,000 gallons and 2,850,000 in the following year.

1916 saw the inception of a new industry for the production of industrial apple alcohols—an industry which developed rapidly but which will not receive detailed consideration here.

Some idea of the growth of this distillation industry can be appreciated from the following figures for the gallons of alcohol produced from apples and pears in the form of commercial alcohol and cider brandy:

1920: 4,085,000 gallons
1921: 3,479,000 gallons
1922: 5,536,000 gallons
1923: 7,216,000 gallons
1925: 6,714,000 gallons
1926: 5,265,000 gallons
1927: 8,244,000 gallons

Cider Brandy

The art of distilling cider originated in Normandy during the second half of the sixteenth century. Gilles de Gouberville, 'seigneur of Mesnil-au-Val', would appear to have the honour of being the first French distiller of cider. The constitution of a profession or closed guild for distillers dates from 1606 and was ratified by the Normandy Parliament on 6th November. It was there enacted that no one could manufacture vinegar, mustard or brandy for sale without belonging to the appropriate Guild.

The technique of production has improved throughout the centuries and now the distillers of vintage brandies can produce remarkably fine products at whatever state of maturity.

Brandies vary in quality with the nature of the cider from which they are distilled, but no list of recommended varieties has yet been produced. The Pays d'Auge provides the very best French cider brandies which have become widely known under the name of Calvados. Such products are made by a double distillation to ensure maximum body, aroma and bouquet in the matured spirit. The caves and cellars of the Pays d'Auge are noted for a wide range of brandies, varying from freshly distilled products to those which have been maturing for over a hundred years, and which can rival the very finest brandies distilled from grape wines.

Ciders for Distillation

It is essential to choose the finest ciders for distillation, but this does not necessarily mean that ciders produced by the aid of pure yeast cultures will give the best brandies. Ciders for distillation should be completely fermented—this for two reasons. Firstly, any residual sugar will be wasted in the distillation process and will represent an actual loss of alcohol. Secondly, it has consistently been noted that dry ciders allowed to remain on their lees for several months acquire an additional bouquet (probably due to autolysis of yeast cells) which is retained in the ultimate distillate.

Ciders need not be clear before distillation, and it is even acceptable to mix the heavy lees into the supernatant cider before leading the cider to the still; discretion should be applied in doing this, for excessive admixture of lees will depreciate the value of the eaux-de-vie. It is important that the ciders should not contain more than 0·3% of acetic acid, otherwise the distillate will lose its high quality. Should it be particularly desired to distil an acetic cider, it is advisable partially to neutralise the acidity before distillation. This, however, is only successful up to a point, for the basic elements added to the cider will preferentially neutralise the fixed acids (malic and succinic) before affecting the acetic acid; as the cider should never be completely neutralised, this process allows considerable amounts of acetic acid to pass into the cider brandy.

The distillation of a cider will provide various fractions such as water, ethyl alcohol and an extended list of other volatile products. The principal known constituents of cider brandy are tabulated below:

		Boiling Point
Primary Products (boiling point below that of ethyl alcohol)	Acetaldehyde	21°C.
	Propionaldehyde	49°C.
	iso-Butyraldehyde	62°C.
	Ethyl acetate	74°C.
Secondary Products (boiling point above that of ethyl alcohol)	*iso*-Propyl alcohol	83°C.
	Butyraldehyde	95°C.
	Propyl alcohol	97°C.
	iso-Butyl alcohol	108°C.
	Ethyl isobutyrate	110°C.
	n. Valeraldehyde	110°C.
	Acetic acid	117°C.
	iso-Amyl alcohol	128°-130°C.
	iso-Amyl acetate	138°C.
	Furfural	162°C.
	Essential oils	

Distillation Apparatus

Three types of plant are in general use:

(*a*) simple stills
(*b*) stills fitted with fractionating columns
(*c*) continuous stills.

(*a*) *Simple Stills.*—These are chiefly used by the itinerant distillers and farmers who distil ciders on their own premises; they are discontinuous and the cider must be put through the plant twice to attain a sufficient strength. All simple stills consist essentially of a heater, a distillation vessel and a condenser. The heater is made of copper and is usually fixed over a brick furnace so that it can be heated directly by a fire. Above the heater is fitted the head of the still and this is extended into a swan neck connected to the condenser. Cooling is effected by a copper coil immersed in a vessel filled with cold water which is constantly being replaced.

Such simple stills are often modified by the inclusion of a heat-exchanger (*chauffe-vin*). This comprises a copper reservoir, of the same capacity as the heating section of the still, which is placed between the head of the still and the condenser. The swan neck passes into the extra section, and there describes a complete turn before leading to the condenser. The 'chauffe-vin' is filled with cider which is later led into the heater after having been warmed by the hot vapours from the previous batch.

Operation of Simple Stills.—The heating section of the still
filled with cider to such a height that experience suggests wi
not cause entrainment of liquid or foam into the condense
The still is warmed by a fire, taking precautions that every pa
of the heating surface that is directly in contact with the flam
of the fire is well covered by the cider within—this to avoid
burnt taste in the distillate.

When distillation commences, the heating is adjusted to pr
vide a slow steady recovery of alcohol. The percentage of a
cohol in the distillate decreases as distillation proceeds. Whe
the alcohol content falls to 12·0% by weight, the receiver
changed and the further distillate is separately collected unt
the alcohol content falls to 2%. This final fraction is mixed wit
fresh cider about to be distilled.

The previous fraction with alcohol contents varying betwee
27% to 29% by weight represents a volume of about one sixt
of that of the original cider, and this is subjected to a secon
treatment in the still. The distiller will naturally need to wa
until he has collected a sufficient volume of first fractionate
liquors to fill his still. During the storage of the once-distille
liquors (say, during three months) chemical changes giving ris
to ether production take place and make a contribution to th
aroma of the product.

The second distillation, to raise the alcohol content to fu
strength, is carried out as for the first treatment. The first sma
fraction is set aside when the distillate measures 0·5% of th
volume of the material being treated (i.e. once-distilled spirit)
This fraction is composed chiefly of acetaldehyde and aceti
ether.

The next fraction is composed of ethyl alcohol, followed b
certain end products. The true brandy fraction is collected unt
the alcohol content falls to 42·5%, and the remainder of th
distillate (down to 4% alcohol content) is collected separatel
These secondary products are largely composed of acetic acid
ether, higher alcohols, furfural and essential oils. The fractio
with alcohol content between 42·5% to 16% is mixed with fres
supplies of once-distilled cider; the last fraction (alcohol con
tents between 16% to 4%) is added to the final liquors fro
the primary distillation and the mixture added back to som
fresh cider for its first passage through the still.

Genuine cider brandy should contain 59-62·5% alcohol.

(b) *Stills with Rectifying Columns.*—These stills are designed to ovide full strength brandies during one passage through the ant. Many types exist, but general details only will be given re. The Deroy fractionating head is made of copper and is aced immediately above the heating vessel. The top surface the lens-shaped fitment is cooled with water; in the middle of e special vessel is a horizontal disc which brings about the ndensation of certain oils which fall back into the heater, hilst the vapours rich in alcohol distil over into the condenser. similar baffle is fitted in the top of the heater itself.

These stills can be fitted with heat-exchangers (*chauffe-vin*) nd the vapours which are often evolved from these vessels can e collected in the usual way.

The Egrot method involves the use of two hollow concentric ylinders. The internal one is full of running cold water which discharged at the top of the outer cylinder and runs over ne outer surface. The alcohol vapours circulate in the annular pace between the two surfaces and are there rectified as they ass round. The rate of flow of the cooling water can be adjusted o give any degree of fractionation needed.

If such an apparatus is carefully used, excellent brandies can e produced by one passage of the cider through the still. Branlies with 57-64·5% alcohol can be collected from the distillation f cider originally containing 3·2 to 4·8% alcohol. Ciders with lcohol contents lower than 3·2% should be passed through the lant twice to give the best results.

Many adjustments to the stills can be made to improve their conomic operation. For example, the spirit collected from the irst distillation of cider may be condensed in the 'chauffe-vin' and re-distilled by the vapours of the heater of the still. Or, again, a series of heaters may be coupled together and the condensation effected either by water or cold cider. The heating of the product to be distilled can be effected by an open fire or by the waste heat from the vapours of the distilling cider.

Distillation of Pomace.—Special precautions are necessary in these stills to prevent any burning of the pomace. If the still is heated by an open fire, it should be protected by a false bottom of straw or wicker. The pomace is mixed with about half its weight of water and either placed in a basket inside the heater or inserted into the heater in the form of briquettes, which c be stirred to avoid local over-heating. Larger installations deri their heat from steam boilers. Usually, the pomace vessels a connected in series; the steam is led to the bottom of the fi vessel, passes up through the pomace, removing and carryi away with it the alcohol contained therein. The process is r peated with the other vessels until the first is exhausted. Th vessel is re-packed with pomace and then becomes the last ves in the series.

Stills used for pomace should always include a fractionati column to remove certain constituents which introduce an u pleasant taste or aroma to the distillate.

(*c*) *Continuous Stills.*—Cider brandy is made to a consideral extent by the use of continuous stills. They possess the advanta of having a very large daily production, of reducing producti costs and preventing practically all loss of alcohol during t processing. All continuous stills are based on the same func mental principles. The cider is subjected to a methodical moval of volatile products by its passage through fractionati towers fitted with special baffle plates. Care must be taken n to collect the spirit in too concentrated a condition—it is usu to withdraw the product from one of the middle sections of t fractionating columns where the alcohol content should be b tween 62·5-64·5% by weight; i.e., the strength at which t natural aroma of the cider is most noticeable. Suitable st efficiently operated produce excellent spirits with normal coe cients for constituents other than alcohol. (Fig. LXXXVI sho a modern Barbet continuous still.)

Storage of Cider Brandy

The strength of spirit that is to be put into storage should reduced to 54-59% by weight—i.e. to the strength at whi the brandy is normally consumed. For this purpose, only ve pure water free from calcium should be used. Brandies do n acquire their full flavour until they have aged for a consideral period. Despite this fact, the greater part of French Calvados sold at an age of one to three years; such brandies are sold 'eaux-de-vie de cidre naturelles', or even simply as 'eaux-de- when sold in combination with industrial neutral alcohol wine alcohols.

Cider brandies as supplied to the consumers in France nor- ally contain 42-47% alcohol when they are young, or 40-45% hen they are mature. On the other hand, newly made spirits e sometimes sold with an alcohol content below 29%, and in ceptional circumstances, below 20%. In such cases, there is danger of compounds other than alcohol causing opalescence the spirit due to the partial precipitation of the ethers and igher alcohols. Such spirits should be cleared or filtered.

Clarification of Cider Brandy

The most usual fining treatment per 100 gallons of brandy is use ⅓ to ½-oz. of isinglass; 3-4½ oz. gelatin; 1½ oz. casein; or pints skimmed milk.

Filtration of cider brandy is most efficient if the brandy is rst well cooled, if possible to 0°C. At this stage, 1½-2 lb. cal- ined magnesia may be added per 100 gallons and the spirit iltered.

Warcollier ('Abnormalities occurring in the manufacture of ider brandies', *Bulletin Association Française pomologique*, 1928) as published a resumé of the various accidents or abnormalities hat may occur during the distillation season. These include randies that contain excess quantities of aldehydes or sulphur ioxide, and a separate report on the latter was presented to the Fourth Congress of Industrial Chemistry in 1925.

Ageing of Cider Brandy

During the maturing process, the brandy loses its raw taste and chemical changes are responsible for the production of etheric substances. Storage should be in wood, using for preference oak casks already used for brandy. New casks should on no account be used as the spirit dissolves tannin materials from the wood. A slight reduction in volume occurs during maturation due to evaporation through the staves, accompanied by a reduction of the actual alcohol content of the brandy.

The eau-de-vie acquires the desired colour from contact with the wood. If colourless mature brandy is required, the barrels must be made of ash wood.

Mature brandies contain higher amounts of acids, aldehydes, ethers and higher alcohols than young products because these classes of compounds are less volatile than alcohol and tend to accumulate during the maturing process. There are other reasons why the so-called 'non-alcoholic' fraction increases during storage. The organic acids increase in the first instance both at the expense of the constituents of the wood and as a result of the oxidation of alcohol and acetaldehyde to acetic acid. The oxidation of alcohol leads to an increase in the aldehyde content. The acids and alcohols slowly interact, giving rise to other etheric compounds.

The efficiency of maturing depends on the nature of the casks and their storage conditions as regards temperature. In Normandy, caves or cellars are preferred so that the temperature does not fall below 12°C., although ageing is much more rapid at 15°-20°C.

Certain treatments are permissible in preparing a cider brandy for sale. Sugar may be added (usually not more than 0·5%); and caramel is allowed for standardisation of the colour, whilst specially prepared apple juice is sometimes added.

Perry Brandy

Brandies produced from perry alone do not possess the same quality as those from cider. It is usual for the perry to be distilled as a mixture with cider.

Brandy from Lees

Spirits of fair quality can be distilled from lees; they may be sold under the designation of 'eaux-de-vie de lies', or, blended with industrial alcohols, they may compete with the very highest quality brandies.

The lees should be diluted with three times their own volume of water. The bottom of the still should be protected by rye straw to avoid burning of the solids in the lees. The liquor is efficiently stirred whilst it is being heated to boiling and the still cannot consequently be closed until ebullition has commenced. Care must be taken to see that frothing, which is most liable to occur, does not cause trouble. Some stills are provided with steam heating and provision for constant agitation of the contents of the still.

An alternative to the separate distillation of the lees is to add them in small quantities to ciders that are intended for distillation. The products possess a very high quality.

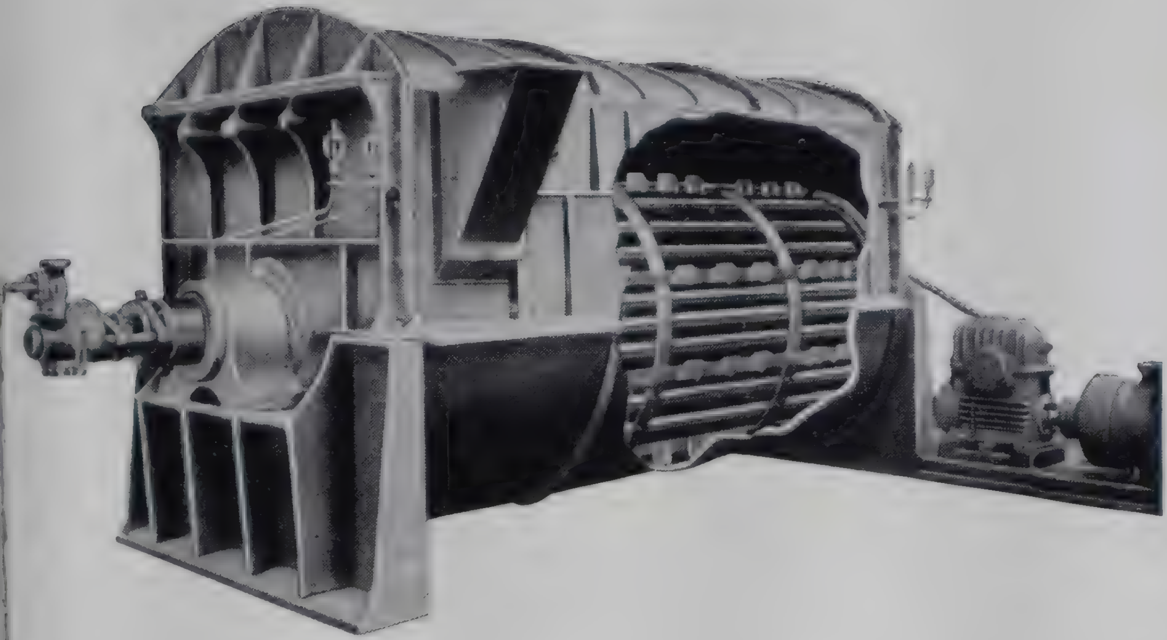


Fig. LXXXIV. Simon Pomace Drier

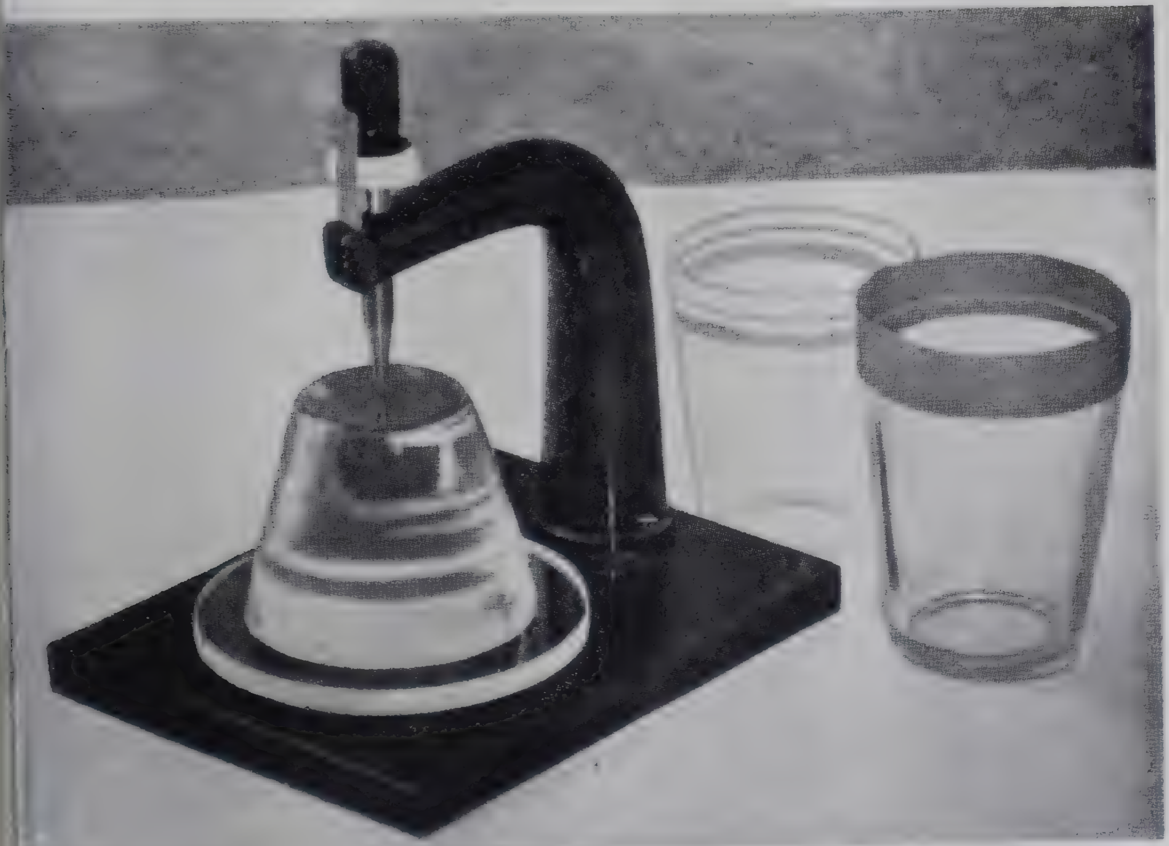


Fig. LXXXV. Ridgelimeter Jelly Tester

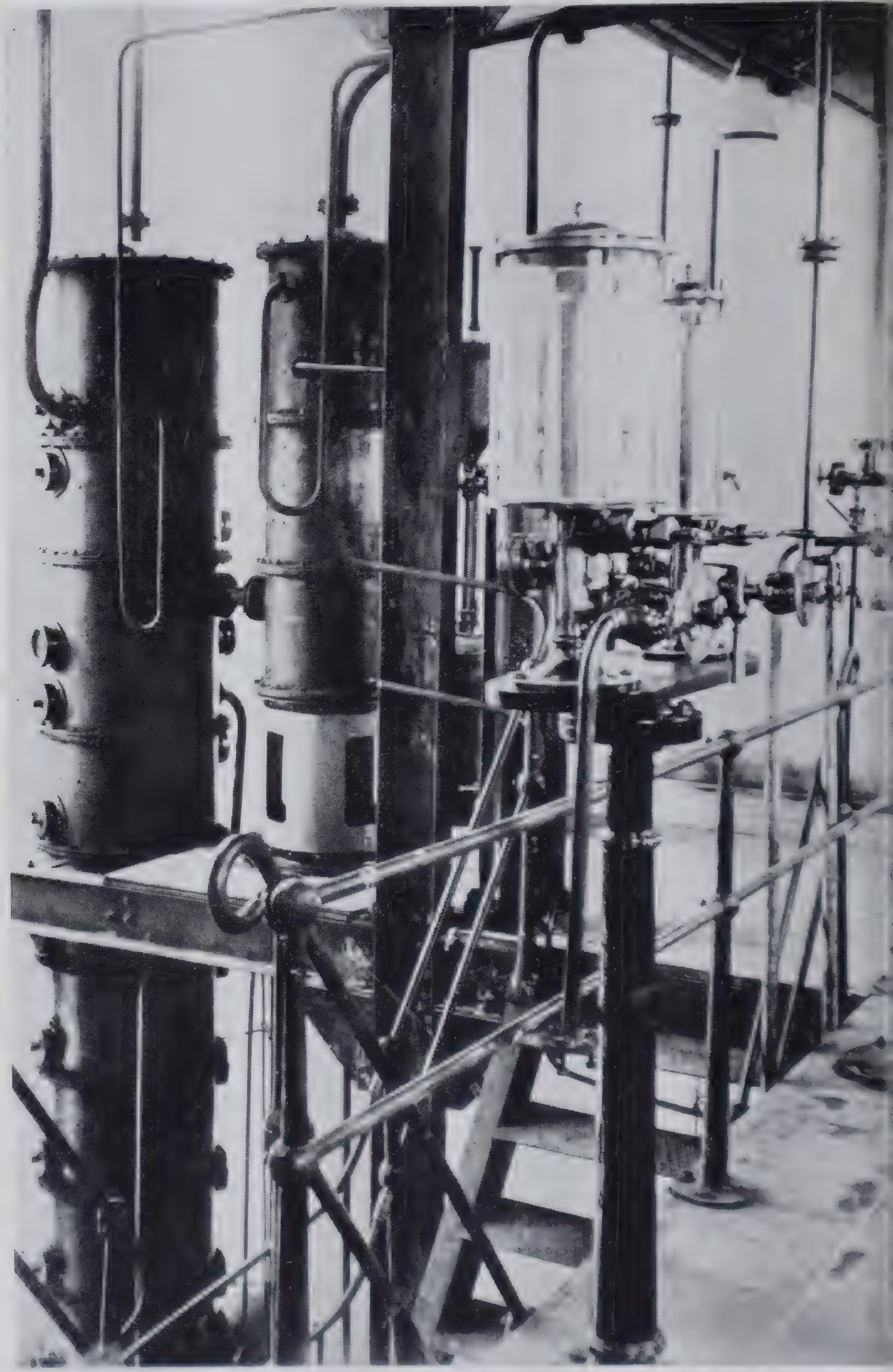


Fig. LXXXVI. Barbet Continuous Distillation Apparatus

Yield of Cider Brandy

The yield of brandy will vary according to the type of appar- us under consideration. Stills necessitating the twofold passage the cider through its columns allow relatively high losses of cohol compared with continuous plants. The losses vary ac- rding to the alcohol content of the ciders; they are greater with ders of 2·4% alcohol than with ciders of 4·8%. In practice, e actual losses vary between 1-10%.

With such varying compositions as occur in pure juice ciders, is impossible to give a close estimate of the yield of brandy btainable from cider. It can be said that 12 gallons of cider ith 4·8% alcohol will provide 1 gallon of cider brandy with 8·25% alcohol; should the alcohol content of the cider be ·4%, the volume required would be increased to 13½ gallons.

Composition of Cider Brandy

The chemical composition of cider brandies varies according o the original composition of the cider and to the precise treat- nent employed in the distillation. The normal stills introduced nany years ago needing a twofold distillation are generally con- idered to be the best. For this reason, many of the most recent p-to-date improvements which have been considered for cider stills have never received widespread approval from the distillers. Again, plants fitted with rectifying columns produce spirits which retain relatively low proportions of non-alcohol constituents. As a general rule, the continuous stills which have been carefully designed produce brandies having a non-alcoholic content very similar to that obtained by the normal stills.

Warcollier recommends the use of double distillation for all brandies that are intended for the full maturing procedure.

Table XXXV provides a number of analyses of cider brandies produced in different ways and stored for various periods.

These and other figures show that for natural cider brandies the following statements are true:

(*a*) The total or coefficient of non-alcoholic constituents is never less than 0·400.

(*b*) The total of ethers plus higher alcohols is always greater than 0·300.

(*c*) The figure for ethers is rarely less than 0·150.

Table XXXV.—Composition of Cider Brandies

(Pomological Research Station of Caen)

		Apparent alcohol	*Dry Extract*	*Acidity*	*Aldehydes*	*Furfural*	*Ethers*	*High alcohols*	*Total of non-alcoholic constituents*
		%	%	(% by weight calculated on pure alcohol in brandy)					
Two-fold distillation in simple still									
1 year old	-	57·1	0·0144	0·0355	0·0160	0·0008	0·6396	0·1698	0·8521
1 year old	-	60·5	0·0232	0·0746	0·0199	Trace	0·3043	0·2249	0·6036
5 year old	-	54·2	0·0088	0·124	0·0279	0·0014	0·2075	0·2284	0·5562
1 year old	-	59·8	0·0000	0·0925	0·0079	0·0010	0·2074	0·2258	0·5096
1 year old	-	55·5	0·0000	0·126	0·0100	0.0011	0·3479	0·2995	0·7508
Continuous Still									
1 year old	-	60·2	0·0000	0·0969	0·0559	0·0026	0·6331	0·1472	0·9095
		54·6	0·0096	0·178	0·0082	0·0040	0·2975	0·0693	0·5055
Still for double distillation	-	42·6	0·7032	0·105	0·0110	0·0013	0·2321	0·1294	0·4504

(*d*) The ethers are nearly always present in greater amounts than the higher alcohols, the reverse being the case with grape brandy.

For perry brandy, the coefficient of non-alcoholic substances is greater than 0·450 and the combined figure for higher alcohols and ethers exceeds 0·350.

Composition of Abnormal Cider Brandies

Apart from the genuine eaux-de-vie de cidre, other products have gained a considerable market in France. One of these is prepared from neutral alcohol distilled from apples in the large industrial distilleries. Such products lack flavour and aroma and are characterised by a quite remarkable lowering in the non-alcohol coefficient. This can be seen from Table XXXVI on opposite page.

TABLE XXXVI.—COMPOSITION OF ABNORMAL CIDER BRANDIES

Sample	1	2	3	4	5
	Non-alcohol constituents expressed as % by weight on absolute alcohol content of brandy				
Volatile acidity	0·050	0·016	0·007	0·019	0·027
Aldehydes	0·013	0·011	0·001	0·008	0·018
Furfural	Traces	0·001	Nil	0·001	0·001
Ethers	0·063	0·066	0·044	0·075	0·105
Higher alcohols	0·125	0·104	0·088	0·097	0·070
Total of non-alcoholic constituents	0·242	0·195	0·139	0·197	0·216
Alcohol content (actual)	62·5	59·7	61·0	57·5	60·1

The data indicate the low figures for acids and ethers. Some spirits offered for sale as normal brandies have been diluted with an equal volume of neutral alcohol.

Only a most searching examination is able to elucidate the cause of these abnormal compositions. Various factors may influence the products, amongst these being the speed of fermentation, the time of contact of the yeast with the liquor after cessation of fermentation, the low alcohol content of the distilled liquors, the lack of etherification on account of the lack of acids, etc. As a safeguard for all producers of the genuine form of Calvados, Warcollier suggests that the product should be standardised and regarded as totally distinct from a product made from the cider produced by a rapid fermentation of apple juice.

Distillery Residues

At the completion of a distillation process, the still contains a liquid which retains all the non-volatile constituents of the cider. This liquor is known as cider 'vinasse'; in France, all fermented products prepared for distillation are known as 'wines' (i.e. grape, sugar beet, apples, grains, molasses, etc.) whereas the residues from distillation are called 'vinasse', no matter what their origin may be.

Their value and composition vary enormously according to the nature of the cider used, the type of plant and the way in which the distillation is carried out. Warcollier has provided some data on cider residues from commercial sized stills of different types, some heated by direct firing, some by steam.

Analysis of Cider Distillation Residues

	% *w/v*
Total acidity (malic)	0·50
Reducing substances	0·10
Sugar-free dry extract	1·30
Organic nitrogen	0·008
Ash	0·253
Alkalinity of ash (as K_2CO_3)	0·155
Alcohol	0·003

Analysis of Ash of Cider Distillation Residues

Phosphoric acid	0·01%
Potassium	0·11%
Calcium	0·029%
Magnesium	0·0015%
Chlorine	0·0056%
Sulphuric acid	0·0074%

Utilisation of 'Vinasse'

(*a*) *As Foodstuff.*—There is a limited amount of these residues used as a warm, tasty liquid food for pigs, although it is usual to incorporate some solid food (bran or potato) with the liquors. The residues from the still have only a small nutritive value, but they can be fed in very restricted doses to pigs, cows and sheep. Cornevin has alluded to the practice of feeding these animals with these residues in the south of France and apparently no ill effects have been observed.

(*b*) *As a Manure.*—When the residues possess a low acidity, they may be cooled and spread over the fields in small quantities in the same way as for urine. The average composition of urine is:

Total nitrogen - - -	0·08%
Phosphoric acid - - -	0·015%
Potassium - - - -	0·36%

Thus it can be calculated that the monetary value of these cider residues is about one fifth of that of urine.

The residues should be distributed over the land in a fresh condition; if this is not possible, chalk should be added until neutralisation is almost reached. The chalky sediments can be used for composts, whilst the decanted liquors can be safely used on cultivated land.

Practical Treatment of 'Vinasse'

The disposal of residues produced by large installations becomes a most difficult matter as the volume may amount to over 60,000 gallons per day. If a large source of running water is available nearby, the freshly cooled residues may be discharged into the river, provided that the flow of the water is 3,000 to 5,000 times greater than that of the residues passing into the stream.

When the water supply is not sufficient for this purpose, the discharge of the residues can be severely criticised on the following grounds:

(*a*) The acidic reaction of the residues can momentarily alter the natural alkaline reaction of the river water.

(*b*) The river may be coloured brown or black by the iron tannates.

(*c*) The residues may carry into the river water certain extractives which favour the development of various groups of lower organisms, such as *Phycomycetes* (particularly *Leptomitus lacteus*); the microscopic filaments of the organisms are dispersed throughout the mucilaginous residues and inhibit the development of the normal vegetative life in the river.

(*d*) As a result of (*c*) there may be a diminution of free oxygen in the river water which prevents the development of normal fish life.

It is thus important to consider in what way such residues can be discharged into rivers so as to avoid pollution. Several methods are available for the treatment of these residues.

Mechanical Treatment.—The residues are stored in very large containers until the solids have settled to the bottom. The supernatant liquor can then either be discharged into a stream with sufficient flow, or spread over the land. If the soil is not cultivated it is usual to collect the liquid residues in small compartments formed by earth partitions 16 in. deep. An arrangement of 8-10 of these compartments should be prepared and the individual sections filled up in turn. The drainage should be adequate so that the liquor does not lie on the land long enough to develop noxious smells.

An alternative method is to continue to feed these liquors on to one given area until complete saturation is achieved. The volume needed for this saturation will depend on the type of soil and its structure. From 88,000 to 265,000 gallons of liquid residues from the stills can be pumped on to 1 acre in one year (i.e. 880 gallons per acre per day for 100 days).

Physical Treatment.—Concentration has been considered in the case of residues from potato, grain or molasses distillation. In the case of apple residues it may be possible to recover glycerin and malic acid from the concentrate. The former constituent is usually present to the extent of 0·01 %. The concentrated extract may either be added to apple pomace to serve as a stock feed, or used as a constituent of organic manures.

Chemical Treatment.—Freshly made lime with high calcium oxide and low carbonate content is sometimes used to neutralise the distillery wastes. These should be treated until they show an alkalinity of 0·1 %, calculated as lime. In these conditions a considerable proportion (up to 50 %) of the soluble constituents of the residues are precipitated. The tannin is completely removed from solution and the treated liquors do not darken in colour or discolour the river water.

Vidal recommends the use of a filter in place of the large sedimentation vessels needed for the above process. The liquid phase can be obtained in a clear condition and the cakes of the filtered material retain part of the extract from the vinasse. The filter cake may have a composition as shown below:

Moisture	64·38%
Mineral substances	22·07%
Organic compounds	13·55%

The mineral elements have been analysed as follows:

Nitrogen	0·34%
Phosphoric acid	0·32%
Potassium	0·13%
Calcium carbonate	11·25%
Ferric oxide	0·93%
Silica	5·06%
Carbon dioxide and undetermined constituents	4·35%

The residues from the stills may also be treated with aluminium or ferric salts, but these materials, according to Warcollier, show no advantage over lime.

Biological Treatments.—The destruction of the organic substances can be effected by natural biological processes, or by the use of activated sludge or bacterial beds. For the latter treatment, the vinasse should be neutralised, decanted from its deposit and diluted with five times its own volume of water. The beds should have an area of 10 sq. ft. for each 100 gallons of diluted liquor. When purification is complete, the liquors can be discharged into a stream of suitable size.

The other treatment owes its inception to Warcollier's work at Caen. The principle of the process is to induce a biological oxidation of the original materials by agitation and forced aeration; by this means, the development of destructive aerobic organisms is ensured. In this way, the so-called 'activated sludges' are formed. The vinasse should be diluted to one hundredth its original volume so that it contains eventually between 100 and 200 parts per million of organic substances.

In certain cases, by using a much less diluted solution containing 0·4% of organic compounds, Warcollier has been able to destroy at least 12½% of these materials in twenty-four hours.

The process, however, was not sufficiently stabilised in 1928 to recommend it for general use by industrial concerns.

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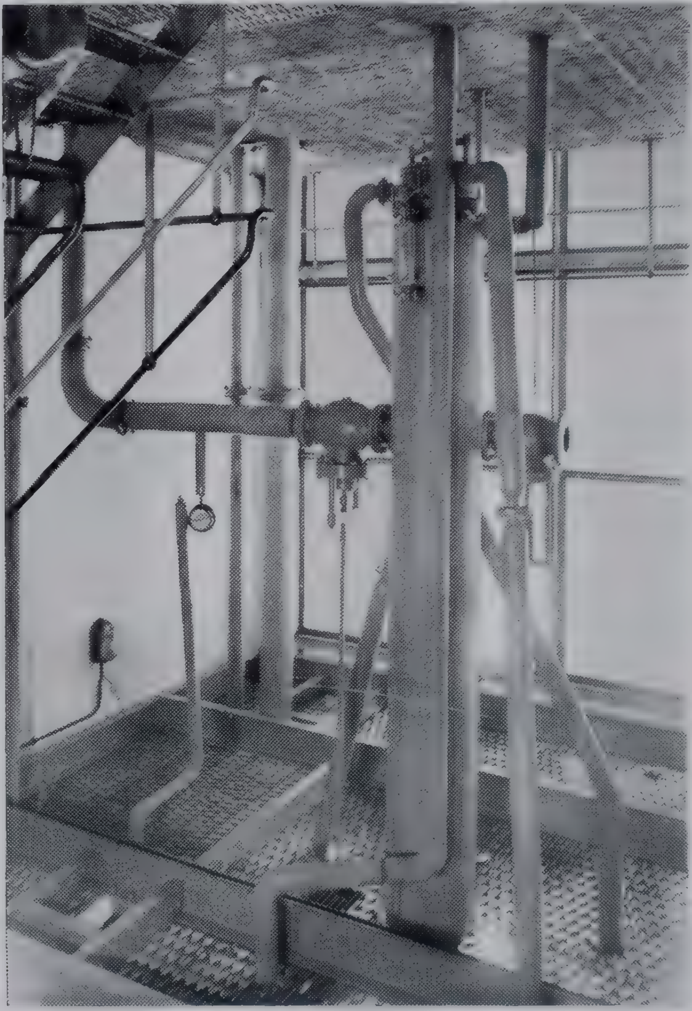

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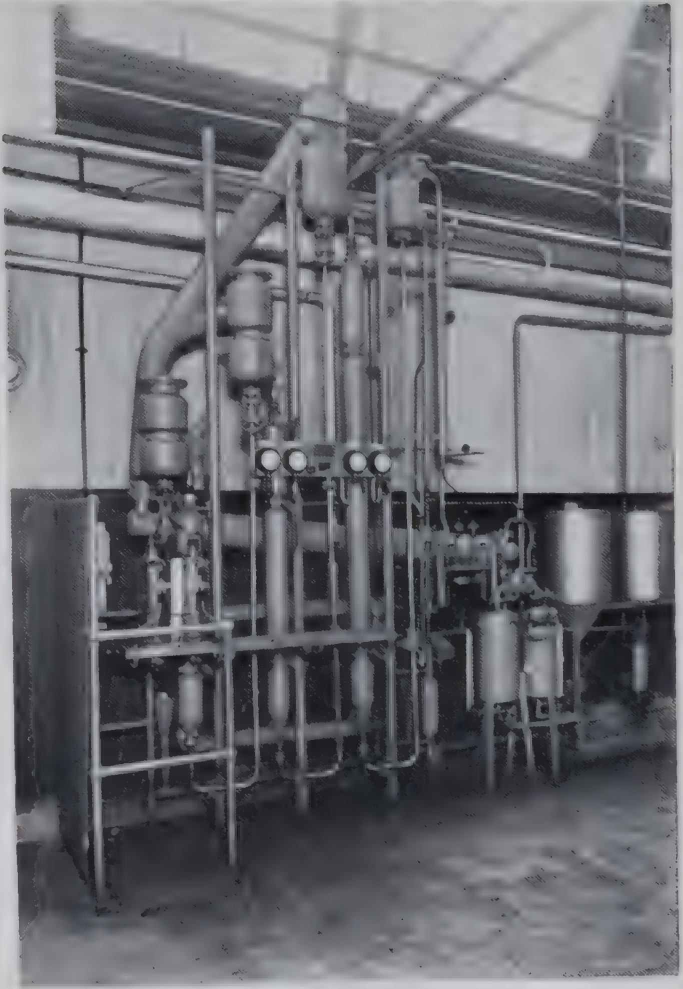

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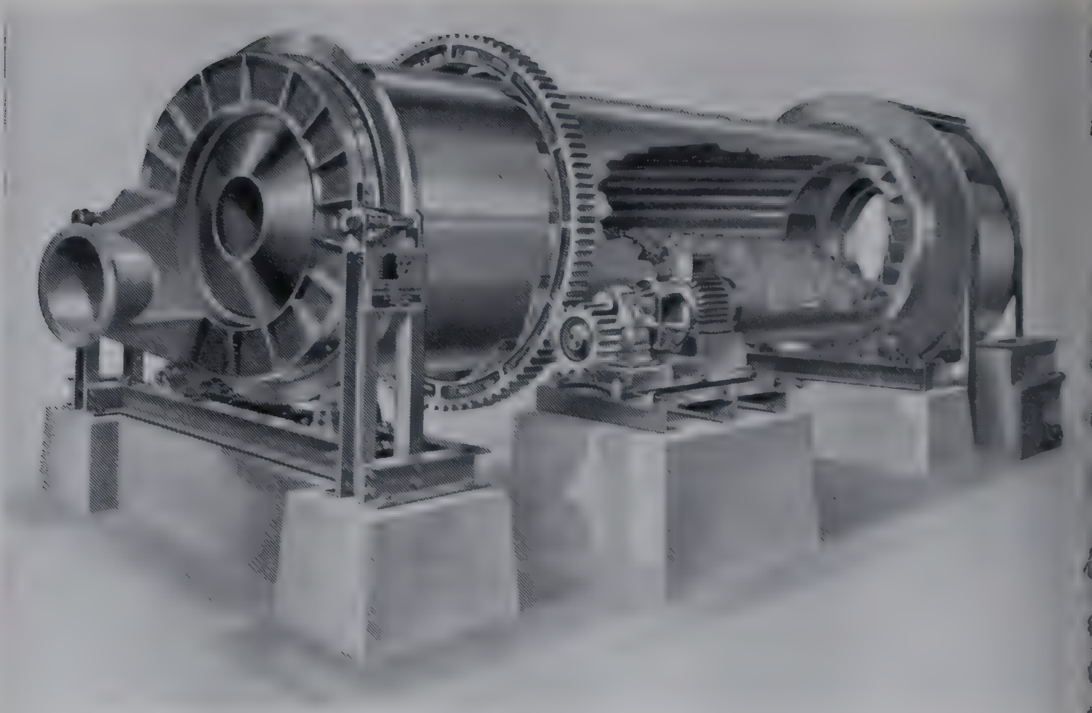

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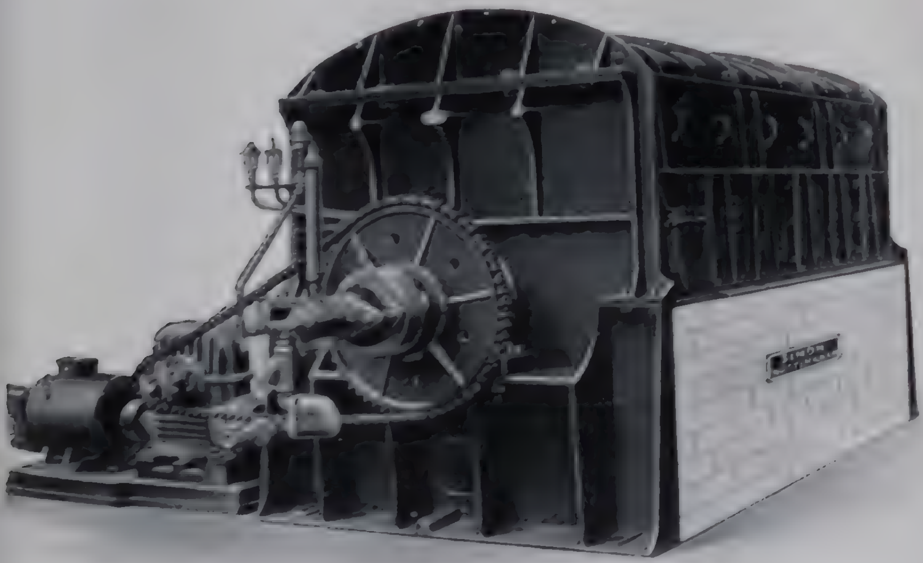

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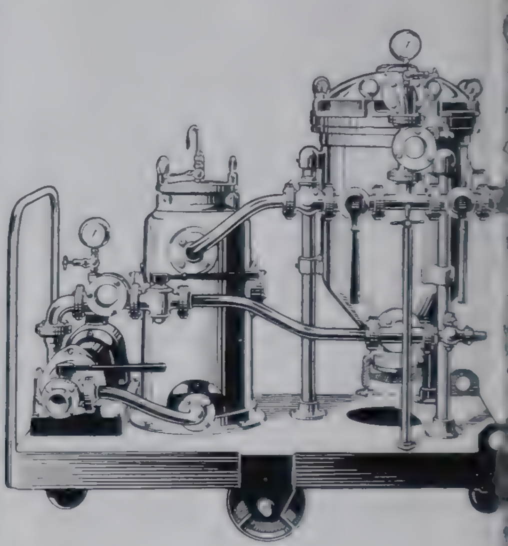

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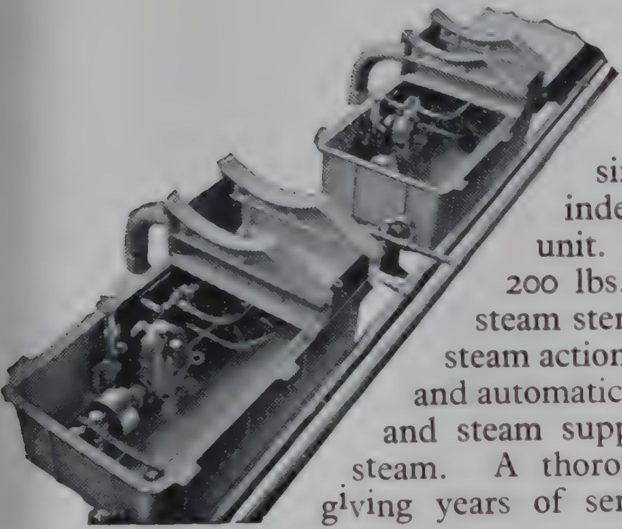

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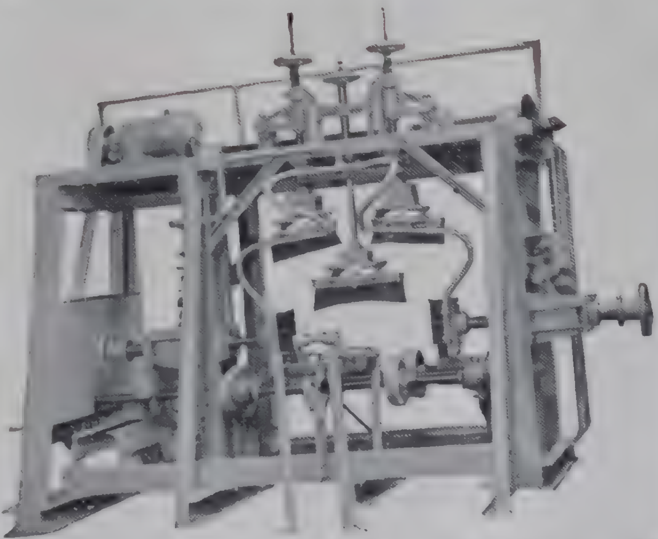

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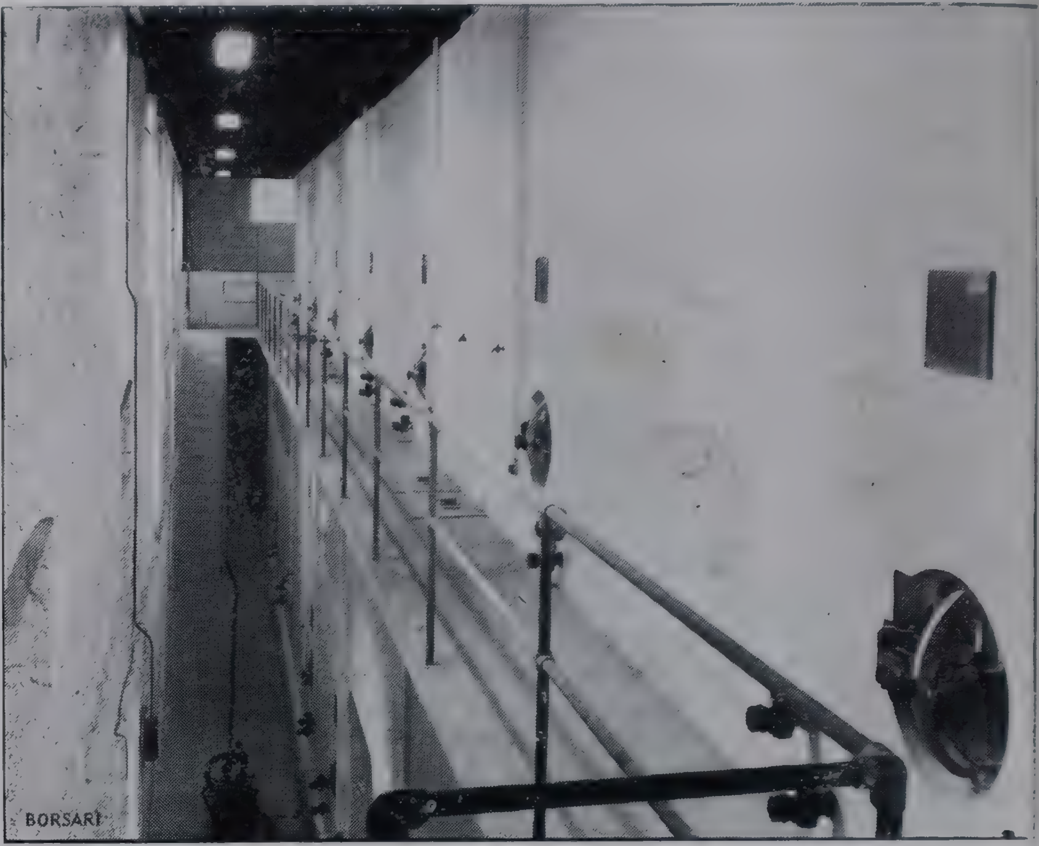

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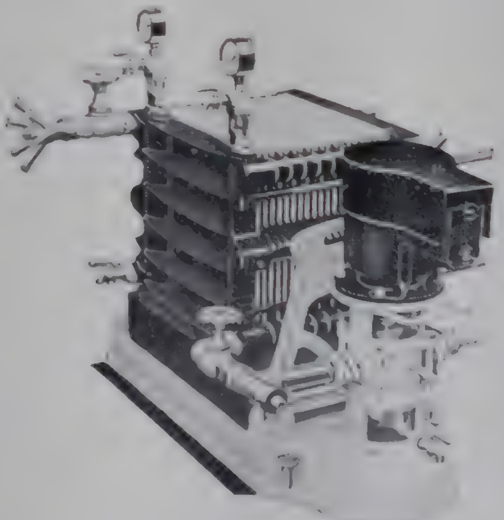

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